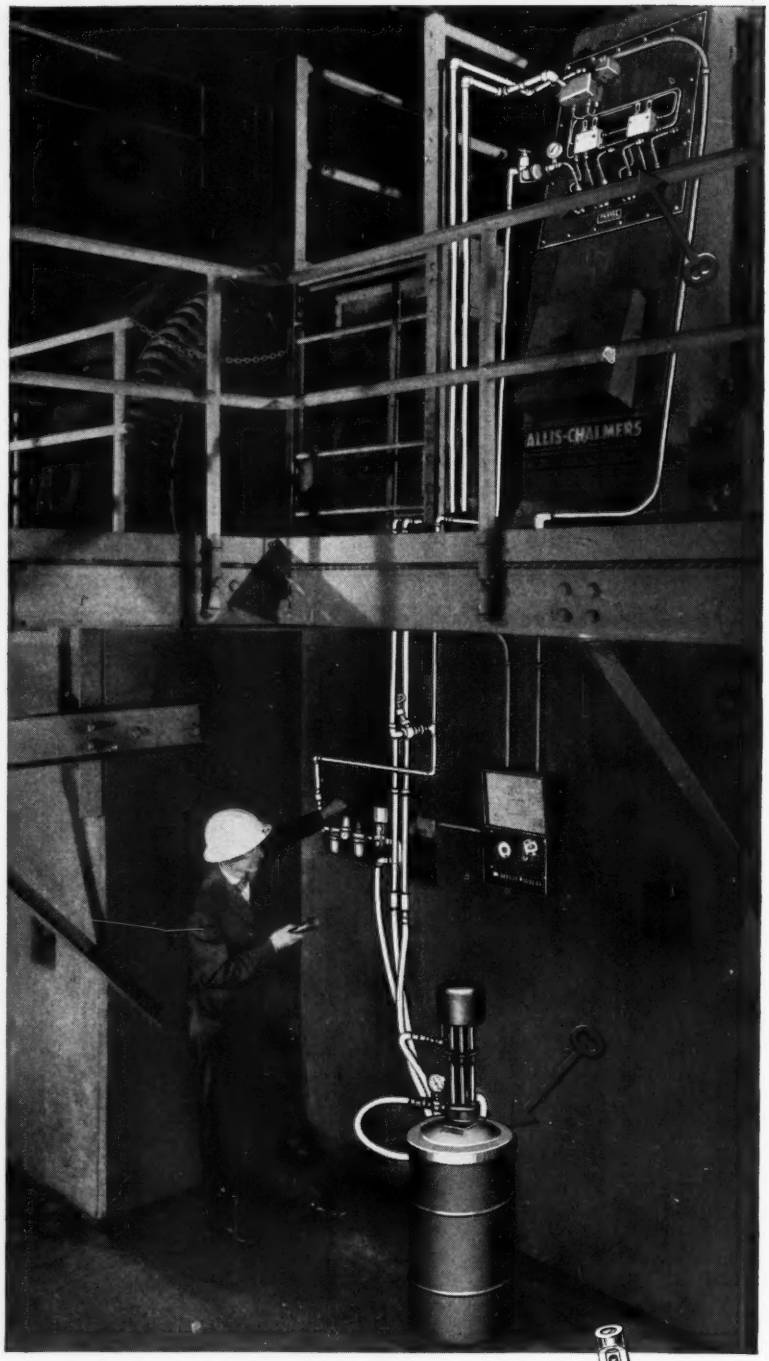
LUBRICATION ENGINEERING

DESIGN APPLICATION RESEARCH EDUCATION MAINTENANCE

HI-SPEED MILLING DEMANDS PROPER COOLANT

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Farval spray lubrication system keeps A-C ball mill running smoothly



FARVAL—Studies in Centralized Lubrication No. 231

Inspecting the new installation of a Farval spray lubrication system on an Allis-Chalmers ball mill at Marquette Cement Company's Milwaukee plant is Erv Klovers, project engineer at Allis-Chalmers.

Mr. Klovers' task was to find an economical and dependable lubrication system to guard the large diameter, wide-faced gears that power the ball mill. So he contacted Farval and together we designed the original spray lubrication system for ball mill gearing. It was completely flexible in arrangement and position—fit his requirements to the letter—showed savings in both lubricant and labor costs.

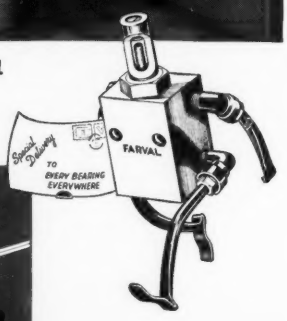
With Farval, gears can be sprayed with the proper lubricant in any amount specified, as often as necessary—without waste or mess.

Hooked up to existing compressed air sources, Farval Spray Valves deliver the lubricant to tooth surfaces through controlled air delivery. Large porting in Farval Dualine valves ensure correct lubricant supply with minimum pressure-drop and very minimum grease separation.

This simple, inexpensive but thorough lubrication system can help you cut maintenance costs as it has for hundreds of others across the nation. See what a Farval system can do for you by asking for Bulletin 26-S. Write The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

KEYS TO ADEQUATE LUBRICATION

Wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.



Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

LUBRICATION ENGINEERING

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

Volume 14, No. 8

August, 1958

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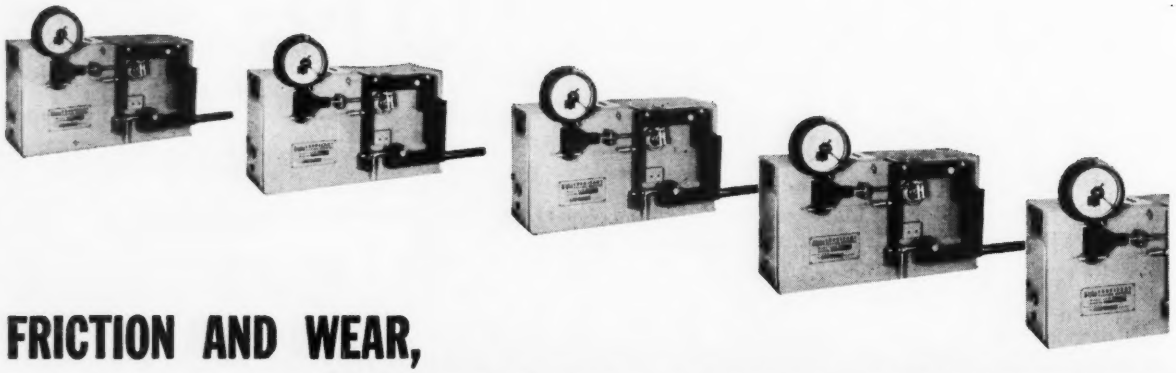


FRICTION AND WEAR, LIKE METAL FATIGUE PROBLEMS, DEMAND COMPREHENSIVE TESTING TO BREAK DOWN THE APPARENT COMPLEXITY

Complete isolation of individual effects is necessary to determine the influence of each condition on boundary lubrication

Although many complex phases of engineering have something in common, there is an uncanny parallel in the study of frictional effects and fatigue effects in metals.

The complexity of fatigue of metal problems involved such effects as metallurgical composition, geometrical shape, size, surface geometry, residual stresses, atmospheric environment, metal working and assembly-induced stresses. Since little was known about the full influence of any of these conditions on fatigue, full-scale simulated service testing of structures and assemblies allowed only composite analyses of these effects. In these composite analyses, however, large variations existed and researchers were unable to pinpoint the particular effect which accounted for the variations.

TESTING IN DETAIL PRODUCED RESULTS

With the advent of World War II, aircraft and military developments forced a more systematic approach to the problem of metal fatigue. A large number of small and relatively inexpensive testing machines were installed to investigate individual effects which were known or presumed to make up the complexity. This approach produced results.

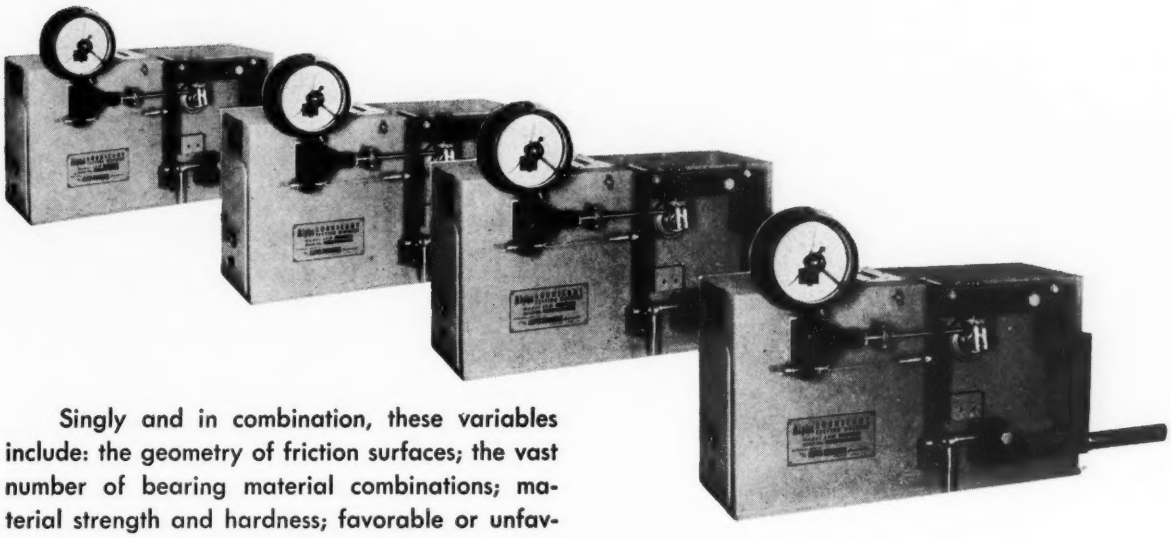
Concentrating on metallurgical composition brought about a knowledge of the decrementary effect of inclusions near the surface. Tests concentrating on geometrical shape disclosed reductions of fatigue strength due to abrupt changes of specimen contour. Surface geometry tests showed the strength-reducing effects of sharp notches. Tests for residual stresses revealed the beneficial effects of surface compression stresses and the detrimental effects of surface tension stresses. Atmospheric environment tests showed the strength-reducing effects of even minor surface corrosion.

Full-scale testing could never have isolated these effects. It wasn't until millions of hours of testing were conducted on small machines that many of the complex phases of fatigue life were cleared up. This made full-scale testing productive and economical.

SAME APPROACH NEEDED FOR FRICTION AND WEAR EFFECTS

The complexity of boundary lubrication rivals the complexity of metal fatigue. It needs, and will receive, increasing attention! Millions of hours of testing must go into the effort to isolate and determine the significance of a multitude of damaging or beneficial effects.

THE BETTER THE TESTING EQUIPMENT . . .
THE LOWER THE COST OF PRODUCTIVE RESEARCH



Singly and in combination, these variables include: the geometry of friction surfaces; the vast number of bearing material combinations; material strength and hardness; favorable or unfavorable formation of surface deposits; surface oxidation; the influence of frictional heat on the bearing metals and the lubricant; bearing pressures; sliding velocity; and so on.

BASIC PROGRAM ALREADY BEGUN

Because of commercial unavailability, we have found it necessary to develop our own research tools for studies in detail. For low velocity EP work, our LFW-1 testing machine, illustrated above, is exceptionally accurate and flexible. We have 16 of these machines operating on a 24-hour-a-day basis, and 42,000 testing hours to date on these machines have resulted in the development of several new lubricant compositions with exceptional characteristics. LFW-1 machines can now be purchased from The Alpha-Molykote Corporation.

SEND FOR FREE LITERATURE

Our Bulletin #106 describes in detail the Alpha Model LFW-1 Lubrication-Friction-Wear Testing Machine. If you have not already received a copy, we will send one to you by return mail.

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Institute Plans Info Program

A call for more and better information on design and use of cast bronze sleeve bearings was issued by George Robinson of The Franklin Institute. Speaking at the first annual meeting of the Cast Bronze Bearing Institute, Robinson stated that engineers are often prone to accept the most readily available information on bearing design. He urged the Bearing Institute to make adequate information on cast bronze bearings easily accessable to engineers.

Organized early this year as an affiliate of the Non-Ferrous Founders Society, the Cast Bronze Bearing Institute will distribute an engineering manual being prepared by the Franklin Institute. In addition, the new institute will conduct an advertising program to publicize engineering advantages of cast bronze sleeve bearings, will hold educational courses for engineers in principle cities and will provide educational material for undergraduate study.

High Speed Seal Material Being Developed

The problem of developing a suitable rotating seal material for potential aircraft operations at high speeds and high temperatures has been partially solved after more than a year of research, according to the report submitted by Horizons Incorporated to Wright Air Development Center, Wright-Patterson Field, Dayton, Ohio.

While additional areas of research are suggested, the report hypothesizes that wear is influenced drastically by oxidation occurring on the rubbing surfaces. With the proper choice of materials, stable, complex oxides are formed which provide the correct solid lubricating film on each component and markedly lower the wear rate as the temperature is increased.

All the materials were tested under conditions of no external lubrication, and the wear behavior of three basic types of metals was studied in detail. The first series was one of pure refractory hard metals. The second set of tests was of binary alloys using the refractory hard metals bonded with nickel. Ternary alloys of pure refractory hard metals bonded with nickel and infiltrated with silver were run in the third set of tests.

Of all the materials tested, the finest results were obtained in the tests in which Kentanium KI62B was run against the same metal at sliding speeds of 14,000 fpm in an ambient temperature of 1100° F.

Additions of silver and nickel were added to the hard refractory metals to determine whether these additives aided in the reduction of the wear rate. It was found that the nickel acts as a tough oxidation-resistant matrix. The silver, softening at the high temperatures, acts as a lubricant. The combination of the nickel and silver additives aids the shearing action between the mating surfaces and lowers the surface friction.

Superior wear qualities were observed in the tests of two ternary alloys which were prepared by powder metallurgy techniques and consisting of high percentages by weight of a refractory hard metal with the nickel and silver additions. These alloys were run against tool steel and inconel. The tests were conducted at sliding speeds of 30,000 fpm and ambient temperatures up to 1350° F. The hard refractory shells which provided the best results contained either tungsten boride or chromium nitride.

The tungsten boride alloy exhibited a constant wear rate at all temperatures against tool steel while the wear rate of the chromium nitride decreased at higher temperatures.

Working also with graphite seals, it was found that an unimpregnated graphite seal coated with an oxidation resistant layer of zirconium carbide showed improved wear properties over a regular graphite impregnated seal. These tests were run against stainless steel type 303 at sliding speeds of 14,000 fpm and at ambient temperatures of 1050° F.

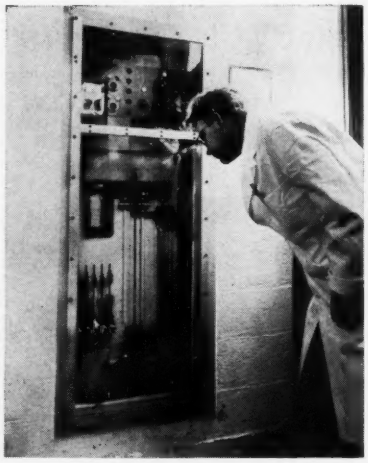
No Human Help

Instruments Make Complete Tests

Complete automation in the chemical laboratory will be introduced in the United States this year.

It will be made possible by a system of instruments that will perform the most exacting scientific tests, record their findings, and take proper corrective action when necessary, all without human help. The system will be offered next fall by Chicago Apparatus Company, distributor of laboratory equipment.

Called the Analmatic, the instruments are made by Baird & Tatlock Ltd., Great Britain, and are extensions of a basic system the company designed and built for the British Atomic Energy Authority. The system reportedly completely frees the scientist from routine analytical work.



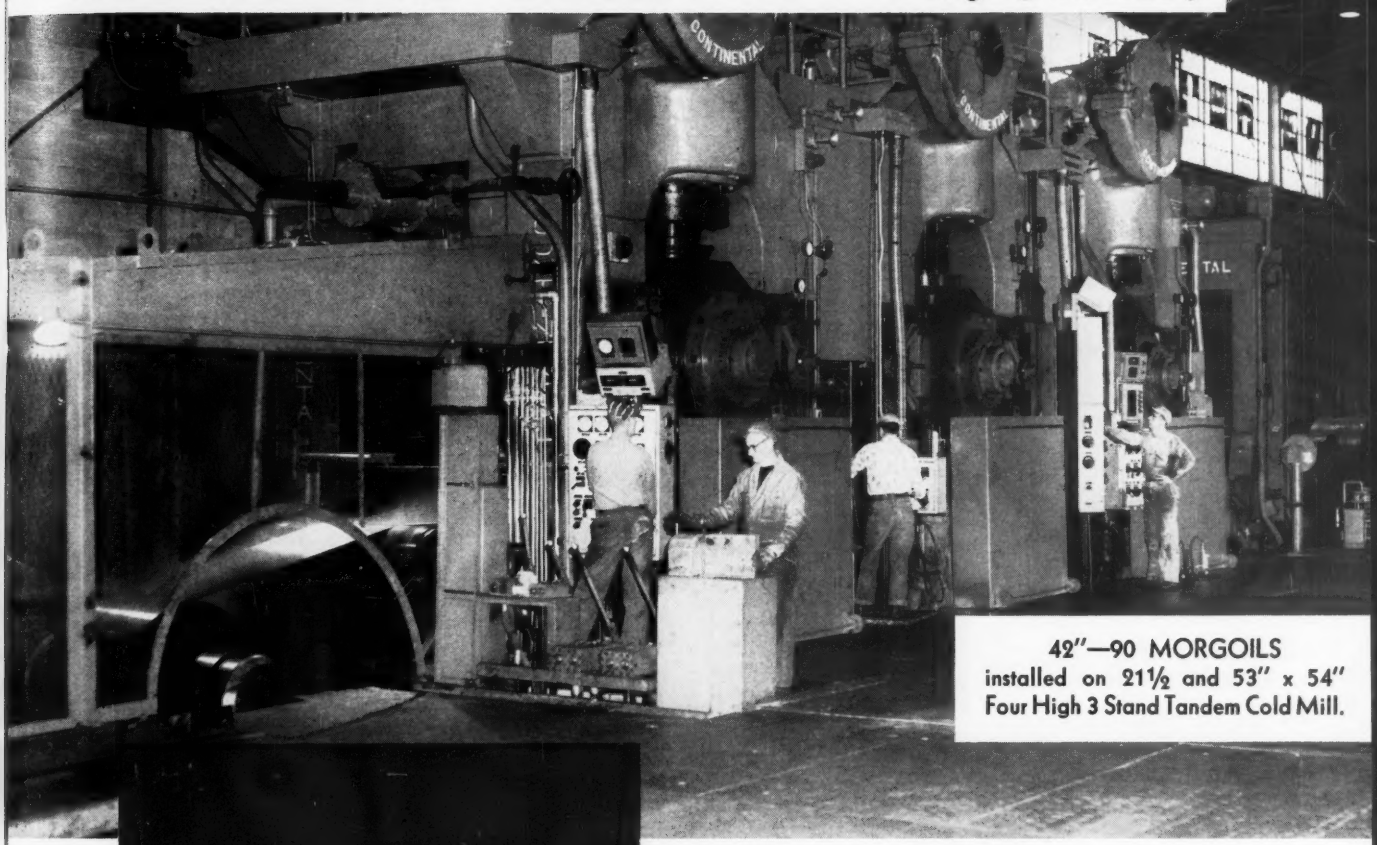
An Analmatic Auto-titration unit has been used by Imperial Chemical Industries Ltd., for more than two years to test the amount of ethylene glycol which is escaping in waste liquids. Since Imperial Chemical installed the first such instrument, more than 25 have been put into use in manufacturing plants in England.

The Analmatic will be displayed for the first time in this country at the National Chemical Exposition by the Chicago section of ACS Sept. 9-12 in Chicago's International Amphitheatre.

The following operations are performed by the Analmatic instrument system without human help:

1. Collects a succession of exactly measured samples of the material to be analyzed.
2. Mixes the successive samples with metered amounts of reagents, as necessary. For example, analyzing uranium involves the addition of ammonium thiocyanate.
3. Heats or agitates the solution as required.
4. Performs the necessary test by color measurement, by titration to pH, by potentiometric or "dead stop" end points, by photometric measurement, etc.
5. Records the test results as graph or dot diagrams, or in digital form.
6. Thoroughly washes all the pipettes and other vessels used to hold liquids, insuring that there is no contamination that will affect subsequent tests.
7. If the analysis shows that the test material deviates from a given critical value or range, a visual or aural alarm is given. If desired, the alarm can be replaced by a control system that will adjust the production process automatically, compensating for the previous error.

MORGOIL BEARINGS *in Action*



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PERSONALS

Morry T. Wakefield has been appointed industrial relations director for Tube Turns, Louisville, Ky., a division of National Cylinder Gas Company, Chicago.

Carl D. Hanson, Houston, Tex., has been appointed unions sales representative for Clayton Mark & Company in the Gulf Coast states. Hanson will represent Clayton Mark, Evanston manufacturer of forged steel unions and forged steel fittings, in south-eastern Texas, Arkansas, Alabama, Louisiana, and Mississippi.

Hugh M. Bone has been named board chairman and treasurer and A. D. Richardson, Jr. has succeeded him as president of The Ironsides Company, Columbus, Ohio, manufacturer of special industrial lubricants. John R. McPhee moves up to vice president and general manager, succeeding Richardson. Other officers are John R. Barcley, vice-president; Robert C. Williams, vice president in charge of research and development; Hugh H. Bone, vice president, production; B. G. Thompson, vice president and E. D. Stackhouse, secretary and assistant treasurer.

STEEN

REINSMA

Henry W. Zimoski, formerly North Hollywood sales representative for Pomona Tile Manufacturing Company, has been named head of the company's divisional office at Memphis, Tenn., according to an announcement by Richard L. Scherbacher, Pomona sales director. In his new position, Zimoski will be in charge of a territory covering southwestern Tennessee and parts of Mississippi and Arkansas.

Paul W. Steen has been appointed manager of distributor sales for the Narda Ultrasonics Corporation, Mineola, N. Y.

J. R. Reinsma, general service manager of the Alemite and Instrument Division of Stewart-Warner Corporation, has been named manager of industrial sales of Alemite lubrication products. W. J. Hawkins, assistant service manager, has been appointed to the post vacated by Reinsma.

ASLE **ASME**

JOINT LUBRICATION CONFERENCE

October 13, 14 and 15, 1958

Hotel Statler, Los Angeles, Calif.

This conference is being planned and held under the joint sponsorship of the American Society of Lubrication Engineers and the American Society of Mechanical Engineers. Registration fee for members is $7.50, for non-members $12.50.

Monday—October 13

Session 1—RADIATION RESISTANT LUBRICANTS

—Development of Radiation Resistant Oils
—The Effects of High Energy Ionizing Radiation on Turbine Oil Performance Characteristics
—Visco-elastic Properties of Greases

Session 2—GAS AND LIQUID FILM BEARINGS

—The Influence of the Molecular Mean Free Path on the Performance of Hydrodynamic Gas Lubricated Bearing
—Axial, Relative Motion of a Circular Step Bearing
—The Gas Lubricated Sector Thrust Bearing
—Elastic and Damping Properties of Cylindrical Journal Bearings
—Analysis and Characteristics of the Three-Lobe Bearing
—The Effect of Offset Loading in Partial Journal Bearings

Tuesday—October 14

Session 3—AIRCRAFT AND MISSILE ACCESSORY LUBRICATION

—An Accessory Manufacturer's Approach to Bearing and Seal Development
—Development of Seals for Rocket Engine Turbopumps
—Mechanism of Gear Lubrication
—A Study of Design Criteria for Oscillating Plain Bearings

Session 4—BASIC STUDIES IN FRICTION AND WEAR—ADHESION AND SLIDING

—Adhesion Between Metals and its Effect on Fixed and Sliding Contacts
—An Investigation of Dry Adhesive Wear (I)
—Wear and Metal Transfer Between Sliding Surfaces (II)
—Transition Temperatures in Sliding Systems
—Metallic Friction and Wear at Elevated Temperatures

Wednesday—October 15

Session 5—BASIC STUDIES IN FRICTION AND WEAR—SPECIAL APPLICATIONS

—Film Formation by an Antiwear Additive in an Automotive Engine
—The Conduction of Current in Bearings
—A Surface Effect Associated with the Use of Zinc Dithiophosphate-Treated Engine Oils
—Wear and Friction of Filled Teflon Compositions in Liquid Nitrogen

Session 6—ROLLING CONTACT FATIGUE

—Operation of Ball Bearings Submerged in Liquified Gases
—Effect of Fiber Orientation, Temperature and by Powder Lubricants on Rolling Contact Fatigue
—Rolling Contact Fatigue of Bearing Materials and Lubricants Combinations
—Materials in Rolling Contact Bearings for Normal and Elevated 450 degree Temperatures

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Atlantic Refining Company of Brazil, Rio de Janeiro

SIR WILLIAM SIEMENS *brought many inventions to the steel industry but none with a greater future than the electric furnace. Knowledge of the carbon arc dated back to 1800. Siemens put it to practical use in 1878, when he built and operated steel-making furnaces on both the direct and indirect arc principles.*

Even then, electric power was too costly, and carbon electrodes of too poor quality, for an electric furnace to operate commercially. It was another 11 years before a successful commercial direct-arc furnace began operating, in France. America's earliest commercial electric furnace (at Holcomb Steel Company, Syracuse, New York) produced its first heat April 5, 1905. It was of 4-tons capacity. Today there are 200-ton electric furnaces and total domestic capacity exceeds 11 million net tons.

Great Names in Steel Making

The growth of the steel industry has been so fabulous that it confers ever-increasing greatness on the work of its pioneers. What William Siemens originated, the industry has since developed to an importance beyond anything he ever dreamed.

This is equally true of more recent technological discoveries.

The lubricant Palmoshield, for example, was developed after World War II to replace imported palm oil for rolling tin plate. It was immediately recognized as an important discovery. But, since then, the importance of Palmoshield has been greatly increased by its successful use for the rolling of light and intermediate gauge sheet, and on long terne and coating lines as well.

Most of the rolling mills of North America are today aware that Palmoshield does much more than protect from dangerous dependence on palm oil from overseas. They appreciate that it eliminates the former need for stockpiling and all concern with artificially influenced prices and supply. They value the fact that Palmoshield is produced in the heart of the steel country, from available domestic materials, and under exact chemical control. Fatty acid content can be controlled within ½%.

Moreover, Ironsides engineers can and do formulate Palmoshield to suit the mill speed, the method of application and the individual preferences of each user, and guarantee that the compound so developed will not vary in uniformity thereafter.

Ironsides lubrication specialists would like to work similarly with you, to help achieve objectives of increased tonnage, reduced costs, and maximum uniformity of mill production. A letter or phone call will bring you complete information and make available the experience of years of successful cooperation with America's major rolling mills.

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Specifically designed for "stop and start" driving!

As auto makers continually develop more critical, more powerful engines—as "stop and start" motoring becomes more a part of everyday driving—good performance from lubricating oils becomes an increasing problem. Foreseeing this trend, Oronite, with five years of research, thousands of laboratory tests, millions of miles of road operation, is proud to announce the FIRST lube oil additive designed to meet the more precise requirements of modern-day gasoline engines—and the engines of the future.

Revolutionary new Oronite "60" Series additives are actually a new approach to compounding motor oils. The modern car engine is engineered to pour in fuel at high horsepower levels. Fuel is not completely burned at low "stop and go" driving temperatures causing gums and sludge to form. Present day compounded motor oils do not disperse these harmful foreign deposits as effectively as is now possible. New Oronite "60" Series additives incorporate an ashless detergent component that virtually eliminates oil ring clogging, reduces cylinder and ring wear to a very minimum. The result is a marked improvement in engine life and service under all types of operating conditions.

Oronite "60" Series additives can provide you an important "first" in marketing a superior compounded motor oil for the present and future. They can be used in compounding single, dual or multi-graded oils of outstanding performance.

Get the complete story on Oronite "60" Series additives. Contact the Oronite office nearest you or write for technical bulletin giving complete proof of "60" Series' capabilities.

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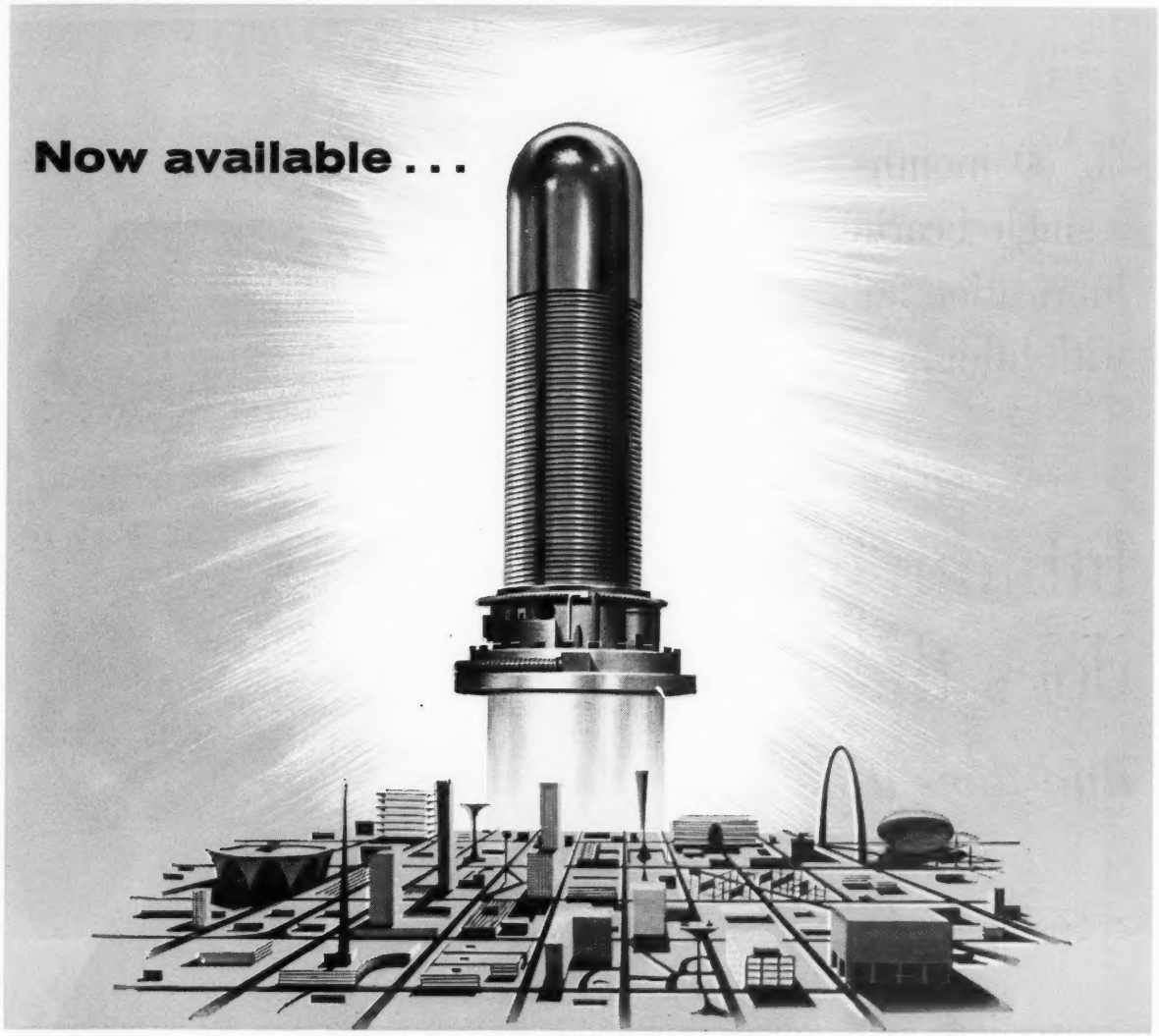

Van de Graaff electron accelerator recently installed at Shell's Emeryville Research Center is one of the most powerful sources of radiation available to industry.

a radiation-resistant grease for commercial nuclear applications
SHELL APL GREASE

Nuclear applications bring new complexities to the field of industrial lubrication. Not only is the lubricant required to withstand unusual service with respect to temperature, speed, load and oxidation, but it is also exposed to the damaging effects of neutron and/or gamma or beta radiation.

To meet this challenge, Shell Research has developed a practical radiation-resistant grease for use in nuclear reactors and their component parts . . . Shell APL Grease.

In Shell Laboratories, comprehensive tests have been conducted with the aid of a three-million-volt electron accelerator, one of the most powerful radiation sources in industry.

Gamma ray tests have shown that APL Grease will withstand an accumulated dosage of 1 x 10^9 roentgens. Another valuable finding reveals that APL Grease has superior thermal stability . . . it lubricates efficiently at 300 degrees Fahrenheit.

APL Grease is further proof of Shell's leadership in lubrication technology—and your assurance that Shell Research is ever vigilant to the pulse of industry progress.

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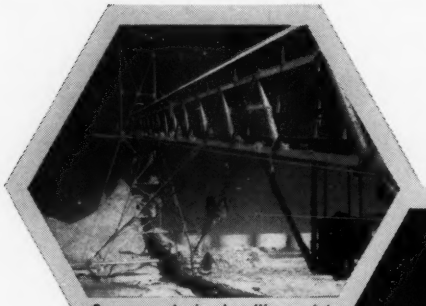
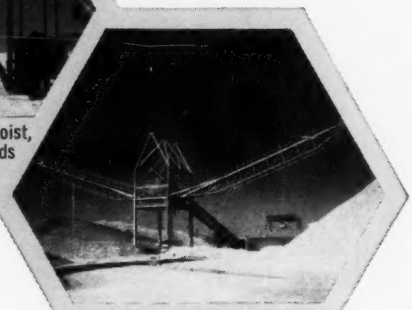


Conveyor-stacker handling moist, sticky material which builds up on the rollers.



Ore unloading conveyor rollers handling 200 tons of ore per hour.

THE PROOF IS IN THE PERFORMANCE...

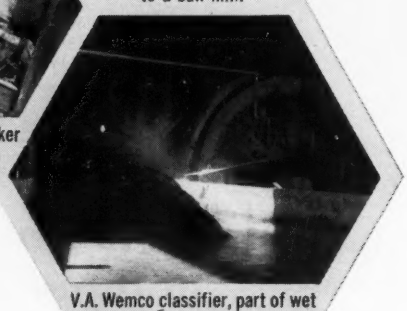
lithium-base grease does the job...

and does it better!

Pinion gear transmitting power from 600 h.p. motor to a ball mill.

Pan Conveyor handling hot clinker (1600°F), roller bearings in dusty, moist atmosphere.

Leach tanks handling hot slurry, agitators driven by Falk gear reducing units.



V.A. Wemco classifier, part of wet grinding system, lower bearing submerged in hot sludge.

Here's a report of our own experience with lithium-base grease under extreme industrial service conditions. Approximately 95% of the grease used in the plant of AMERICAN LITHIUM CHEMICALS, Inc., our subsidiary at San Antonio, Texas, is lithium-base, one-type grease. In fourteen months operation we have not been able to trace a single cause for bearing failure to the lubricant used. The on-the-spot photos above give graphic evidence of the rugged bearing service requirements in this plant where lithium ores are processed into high-grade lithium hydroxide, itself an important ingredient in lithium-base grease. Performance like this is why grease chemists, manufacturers, marketers and users all attest to the superiority of lithium-base... the *one* grease in place of *many* for efficient and economical operation.

Want to know more about TRONA lithium hydroxide monohydrate? Send for our technical bulletin on this important chemical ingredient in lithium-base greases.

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If you think the days of the precise craftsman are a thing of the past, you ought to take a tour through Arch Gear Works at North Quincy, Massachusetts.

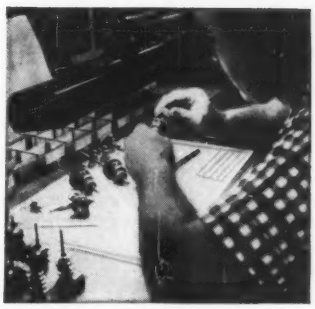
There, you'd see some of the nation's foremost specialists in precision gearing going about their jobs with the most painstaking accuracy.

Such accuracy is absolutely vital at Arch Gear Works, because this unusual firm produces amazingly intricate mechanisms involving as many as 50 tiny precision gears... gears that automatically control the speed and torque of sensitive electro-mechanical devices.

In this highly complex, precise operation, Cities Service is the choice of cutting oils for a very simple reason: Cities Service Cutting Oils deliver .0002 tolerances and the finest possible finish. Few oils can match this performance.

With equally outstanding results, Arch Gear Works uses Cities Service Anti-Corrode to protect its gears during shipment, and Cities Service Pacemaker Oils for general lubrication and hydraulic machinery.

But you needn't operate a gear works to prove that Cities Service lubricants are geared to *your* operation. Simply talk with a Cities Service Lubrication Engineer. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N.Y.



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- O. L. King & Co., 782 Minnesota Street, San Francisco, Calif. Valencia 6-6701
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NEW PRODUCTS

NEW SILICONE COMPOUNDS

Three new silicone rubber compounds designed for fabrication of O-rings, gaskets and other seals have been added to the standard product line of the Silicone Products Department of the General Electric Company. Designated SE-362, SE-372, and SE-382, these compounds readily meet or surpass the requirements of AMS 3303C, 3304B, and 3305C respectively. Featuring tensile strengths of 1000 to 1200 psi and compression sets ranging from 17 to 19 per cent after standard cures, these new compounds reportedly offer better physical properties than earlier Class 300 compounds. Improved tear strengths are another feature, ranging from 65 to 75 pounds per inch after an oven cure of four hours at 480 degrees. Linear shrinkage during cure is less than 2 per cent permitting use of these new compounds in most molds designed for production of organic rubber parts. Because of their low compression set and good oil resistance, SE-362, SE-372, and SE-382 are especially suited for O-rings and other seals used in contact with petroleum oils and most hydraulic fluids. Astm requirements also met by these compounds are those of TA604 for SE-362, TA704 for SE-372, and TA805 for SE-382.

SOLID FILM LUBRICANT

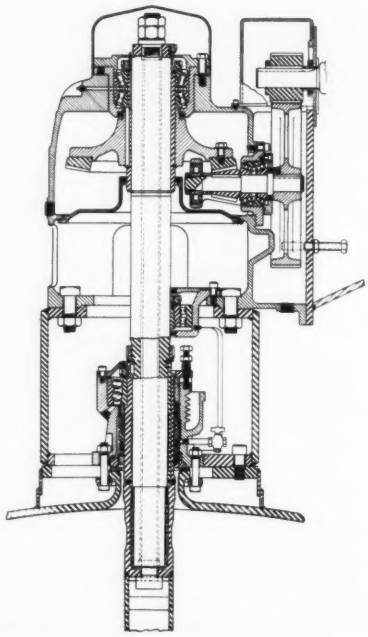
A resin bonded solid films lubricant, called Surf-Kote H-108, is now available from the Hohman Plating & Manufacturing Co. H-108 contains a molydenum disulfide compound that is bonded directly to metal surfaces by a resinous material, forming a solid, dry film of lubrication. This film prevents contact between metal surfaces providing a low coefficient of friction which eliminates galling, seizing, cold welding and fretting corrosion. The lubricant remains uneffected by humidity or unusual atmospheres, and is impervious to oils, greases, solvents, acids and alkalis. For further information on H-108 solid film lubrication, write direct to Sales Promotion Dept., Hohman Plating & Manufacturing Co., 814 Vermont Ave., Dayton, Ohio.

NYLON AIR HOSE HAS RECOIL ACTION

A new lightweight nylon air hose for use with pneumatic tools incorporates snap-back action to keep it out of the way of work. Said to be tough, heat resistant and unaffected by oil, kerosene and gasoline, it is recommended as a general purpose air hose for industrial plants, machine shops and gas station lubrication rooms. Called Nycoil hose, its long-life characteristics result from the Plaskon nylon of which it is extruded. The new hose will withstand high operation pressures as well or better than rubber hose; its abrasion and chemical resistance are superior and its smooth inside surface insures less resistance to air flow. The coiled form in combination with a portable attachment provides unlimited flexibility and mobility of position. It is ideally suited, according to the manufacturer, for use with portable pneumatic equipment—air tools, air staple guns and spray guns—and is especially advantageous when incorporated in an overhead installation. The hose if offered in 3/16-in. ID and 1/4-in. ID sizes, in a standard 25-ft. length, with flare fittings one each end. If shorter lengths are desired, the hose may be easily cut and flared with a standard copper flaring tool. A product of Nycoil Co., Westfield, N. J., the hose is available through air tool distributors.

MAINTENANCE GEAR DRIVE

A low maintenance gear drive with a silent operation is intended for use on 300 gallon through 4,000 gallon agitated



vessels. While its chief feature is its freedom from the involved and costly maintenance requirements of previous agitator drives, the new unit, designated the B H Drive, offers many additional design advances. Additional design and application information can be obtained by writing for bulletin #972 to the Pfaudler Co., 1065 West Ave., New York.

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BARAGEL* provides EFFICIENCY

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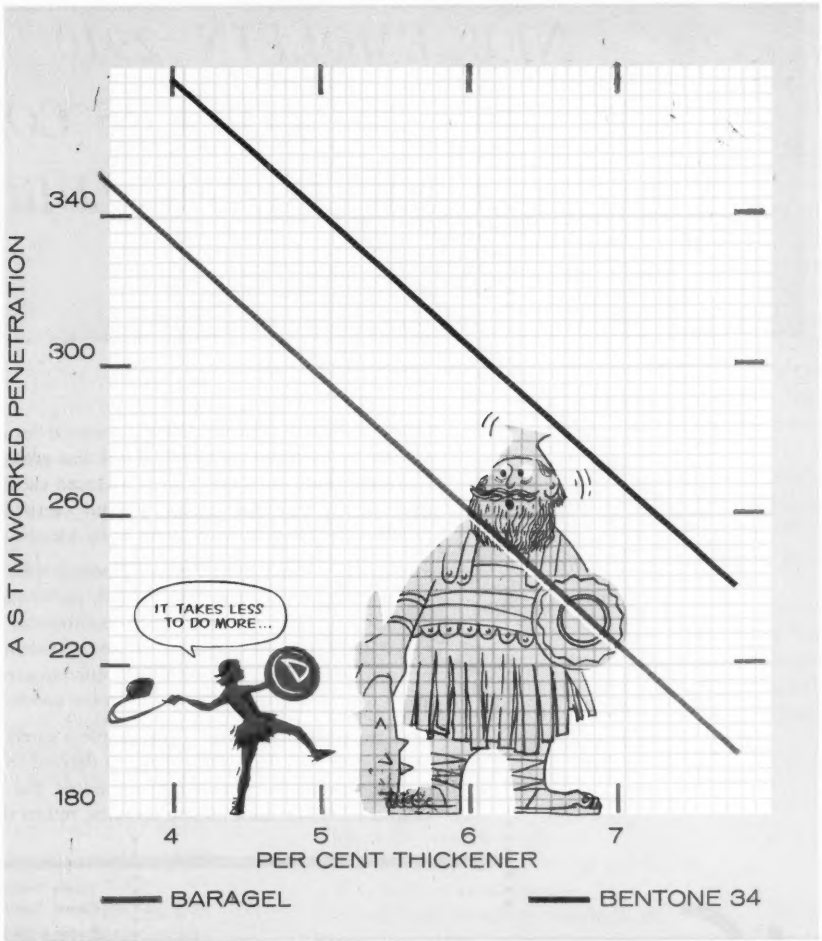
BARAGEL is considerably more EFFICIENT than Bentone 34. In many oils, 15% to 20% *less* BARAGEL is required to prepare a grease of a given consistency.



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NEW EMOLEIN® 2910 LOWERS COST OF SYNTHETIC LUBRICANTS

Emolein 2910 Lubricant Ester, formerly designated Emery 3033-S, is the answer to lower-cost synthetic fluids and greases required by the jet age. In synthetic fluids, total cost can be reduced substantially by blending Emolein 2910 with an azelate diester without sacrificing performance. In greases, Emolein 2910 can be used alone or by blending with other fluids.

Emolein 2910 dipropylene glycol dipelargonate is a new type of diester based on inexpensive pelargonic acid. With performance testing having confirmed its utility, it joins the established members of the Emolein line of diesters, Emolein 2957 di-iso-octyl azelate and Emolein 2958 di-octyl azelate, whose performance under the conditions encountered in modern jet engines has given them a recognized position in the synthetic lubricant field.

One more important fact: The Emolein esters are *not* dependent upon imported raw materials. Since they are derived from abundant domestic tallow their future supply is practically unlimited. For more detailed information on Emolein 2910 or the Emolein azelates, return the coupon below.

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Lube Lines

by A. F. Brewer*

Machinery Overhaul

Industrial or power plant machinery overhaul has a relation to lubrication because the wear element is involved. Management is interested because overhaul necessitates that production schedules must be disrupted when machinery is out of service for this purpose.

Why It Is Necessary

Several conditions of service impose this requirement, i.e.

1. Wear of bearings, gears, etc.
2. The need for cleaning.
3. Change in metal structure due to stresses and strains which may reduce load-carrying ability.

Wear is generally contingent upon

1. Cleanliness of the lubricant.
2. Load-carrying ability, and
3. Extent of overload.

Lubricant contamination can be developed by the machine itself through minute metallic wear particles, or by contributing operating factors such as moisture, dust, dirt, chemical fumes or, in engines, from fuel combustion soot.

When we are dealing with a considerable volume of lubricant as in an oil circulating system or centralized pressure greasing system, the built-in provisions for filtering or straining out of extraneous foreign matter promote greater cleanliness of the lubricant. Bearing, cylinder wall and gear tooth surfaces are thus protected from service wear.

Unit or built-in lubricating systems such as are used in certain electric or gear motor bearings or in small gear sets require careful attention to housing seals and breathing facilities which may permit entry of dust, moisture or acid fumes.

Overload and the load-carrying ability of bearings, gear teeth and their respective lubricants must be considered together. There will be less chance for premature wear due to failure of the lubricating film when there has been complete cooperation between the designer, the lubrication engineer and plant management members responsible for lubricant selection. They must seriously consider the possibility of film failure because it can become so costly, viz. in gear teeth where cracks and pits have started, to enable oil to be trapped and subject to hydrostatic pressure under load. Research has indicated that progressive extrusion of these cracks and pits can result, ultimately ruining the meshing relation of the gears and requiring replacement.

The need for cleaning will depend upon the service conditions. Some phases of production and assembly will be cleaner than others. In steel rolling, metal working and the cement mill, for example, the chances of keeping machinery relatively clean will be less than in the production of electrical or refrigerating machinery. Some industries have to resort to drastic methods to maintain acceptable cleanliness, viz. in meat packing where certain machines have to be hosed down regularly with hot water.

The procedure obviously must be planned according to the product, the plant conditions and the question of how well the equipment is housed and sealed.

Change in metal structure can develop either with bearings or gears according to the service conditions. With non-ferrous bearing metals, the change can involve chemical reaction in the form of corrosion, as with copper-lead or other lead base alloys when the oil is of such a nature as to preferentially attack the lead. This is why modern heavy duty motor oils contain special inhibiting additives to protect the bearings.

Change in gear tooth structure can also be brought about by corrosive wear which results from chemical reaction with the metallic surfaces. Often this effect can be accelerated by moisture accumulation in gear housings or oil reservoirs.

In turn, load and shock can cause physical change in metal structure which reduces the strength of the metal. This can be particularly serious where steel-to-steel is involved as with gear teeth. Unexpected shock load can cause fatigue breakage which is of a progressive nature, normally starting as a slight crack.

How Often To Overhaul

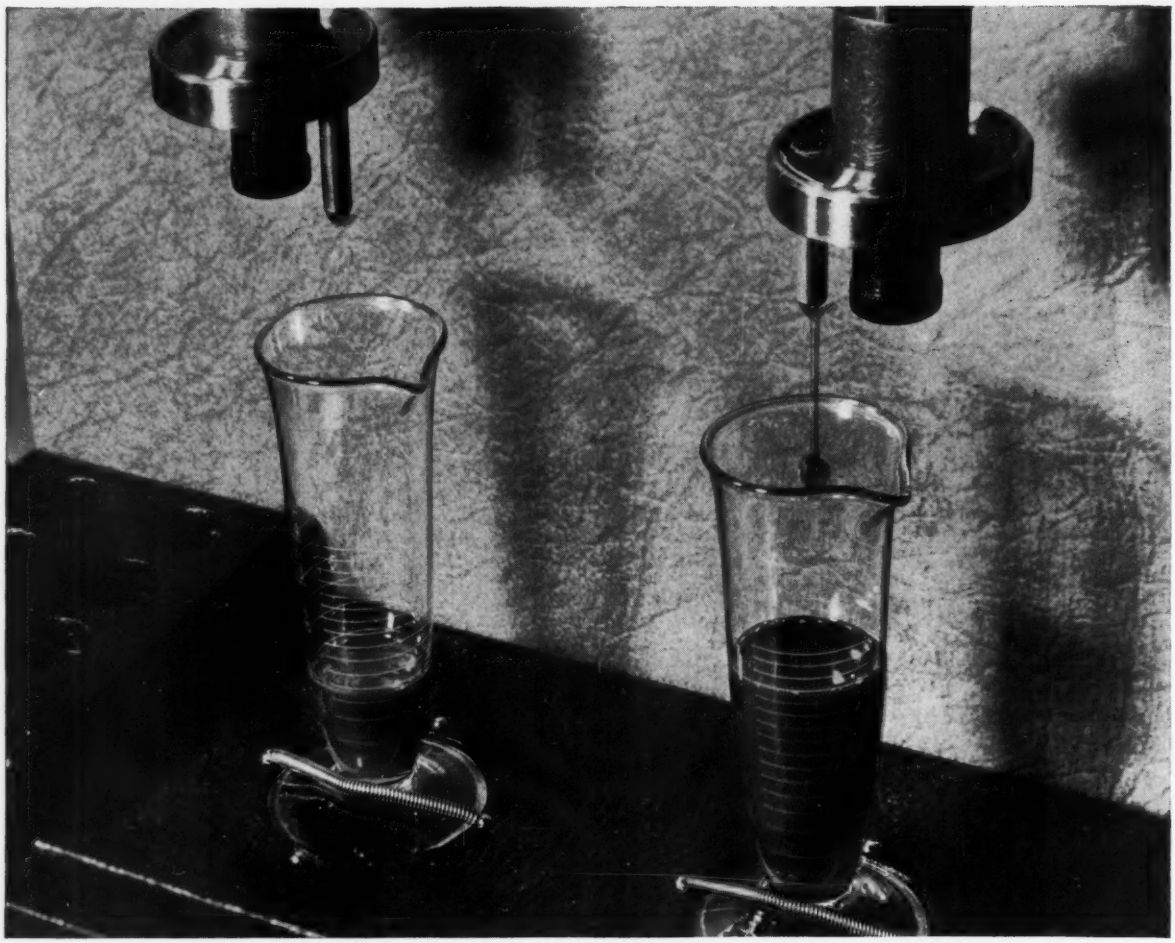
This will depend upon

1.—Severity of operating conditions.
2.—Service cleanliness.
3.—Effectiveness of lubrication.

Some industrial operations are inherently more clean than others, being freer from foreign materials which could contaminate lubricants and promote wear. Mining, metal working, construction and cement are typical of service where the air may have a high dust content and where other solid abrasives can accumulate. Here, relatively frequent cleaning will postpone

(*Cont. on p. 359*)

* Consultant, and author of *Basic Lubrication Practice*.



The oils collecting in these graduates are being forced, at 100 psi, through two sintered bronze bearings. Although each oil has the same viscosity, the Suntac on the left is leaking *only one quarter as much as* the straight oil on the right.

Desk-top demonstration proves that SUNTAC HYDRAULIC OILS can cut your oil losses . . . up to 75%

Suntac® oils are competitive in price, competitive in quality, *and unique in their ability to reduce oil leakage without costly shutdowns.*

Suntac oils are high-quality, exceptionally stable mineral oils especially compounded to reduce leakage. Experience proves that they give longer pump and seal life with higher overall operating efficiency.

See for yourself how a Suntac oil can cut your oil costs. A simple desk-top demonstration will show you how.

Ask your Sun man to show you how others have reduced oil consumption, or write to Dept. LE-6.

Industrial Products Department

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LUBRICATION ENGINEERING

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

Journal of the American Society of Lubrication Engineers *Vol. 14 No. 8 August 1958*

Exhibit Offers Sales Opportunities

Americans will be able to BUY their way out of the recession when advertising and sales executives SELL themselves back to normal prosperity. One avenue of such salesmanship will be found in the exhibit areas of our 1959 Annual Meeting. There, in Buffalo's Hotel Statler on April 21, 22 and 23, sellers of products that will help assure industry more continuous operation with reduced maintenance costs will have a chance to display these products to their pinpointed market.

Many manufacturers who should be exhibiting at this meeting will not be doing so. Due to the relative newness of our Society, these producers are unfamiliar with the benefits that will accrue to them when some 2,000 leaders in the specialized field of lubrication have an opportunity to view their products and services. These producers do not know that each one of the men present is in a position to purchase the products that will service billions of dollars worth of industrial equipment. They are unaware of the fact that one inquiry from a member of this highly specialized market is worth hundreds of inquiries from a more generalized audience.

The National Exhibit Committee and its chairman, Robert J. Torrens, are doing yeoman duty in acquainting producers with this time-tested sales opportunity. But these men cannot, of course, be expected to accomplish what several thousand can. The company for which you work may be one that will profit greatly from exhibiting its products at the 1959 Annual Meeting. And each *Lubrication Engineering* subscriber and/or member is in a position to give his company's advertising manager or sales manager the kind of information about the lubrication engineer and his functions that will illustrate how useful an exhibit space will be to his company.

In order to assist in disseminating this information, the National Office has prepared a brochure giving general information to those interested in exhibiting at the 1959 Meeting. This brochure will be mailed free of charge on request (see coupon on page 359.).

The 1959 Annual Meeting promises to attract an unprecedented number of men in the position to purchase an unprecedented number of products. And an exhibit at this meeting can produce many dollars worth of sales and an immeasurable amount of goodwill.

J. D. Lykins, *President*

Lubrication of Outboard Motors

*by W. C. Conover**

INTRODUCTION

A better understanding of the problems faced by outboard motor builders is necessary in order to enable the petroleum industry to provide better products specifically designed for this rapidly increasing market. This article contains no material of a detail technical nature. It does, however, present problems that have plagued outboard engine builders for many years. Engine builders have gone far to solve some of these problems, but it is apparent they must seek the cooperation of the petroleum industry.

By bringing forth the engine builders' point of view on some of these problems, it is hoped that the petroleum industry will recognize the need of research and development work in an area that is beyond the scope of normal engine development. Any major improvements in the lubricant must be in general use and widely distributed before the engine designer can make use of them in his designs.

This article will deal solely with engine lubrication which is accomplished by mixing the lubricant in the fuel.

GROWTH OF THE INDUSTRY

It might be well to point out here the growth of the outboard motor industry in the last seven years. Between 1951 and 1957, annual unit sales of outboard motors jumped over 100%, according to figures of the Outboard Motor Manufacturers Association. The increase in horsepower is even more spectacular. In 1951 the average horsepower per unit was 8.9. This increased to 16.3 horsepower per unit average in 1957. It is expected that this upward trend will continue.

A sales department estimate indicates that approximately 65 per cent of 1958-1959 production will consist of motors 18 horsepower or larger. The trend toward larger motors has been increasing rapidly in recent years. It is felt that this trend not only will continue, but more likely than not, will increase. This can only mean that sales of gas and oil to outboard motor owners will increase substantially.

As of December 1957, it was estimated there were 5,908,000 power boats of all descriptions in use. Of this quantity 5,190,000 were powered by outboard motors. This means that of all power boats in the United States, 87.85 per cent are powered with outboard motors.

To bring this closer to the petroleum industry, these figures have been reduced to gasoline consumed. It has been estimated that total gasoline used annually in all types of power boats approximates 375,000,000 gallons. Of this amount, 259,000,000 gallons are consumed in outboard powered boats. Assuming a normal ratio of gasoline to oil, it is estimated that outboard motors consumed approximately 13,000,000 gallons of lubricating oil in 1957.

With the steadily increasing demand for outboard motors, and the steadily increasing horsepower per motor, it can be readily seen that the demand for petroleum products will be increased substantially. Thus, here is a market offering excellent potential for increasing sales of petroleum products.

DEFINITION OF AN OUTBOARD MOTOR

The present-day outboard motor used on the American scene scarcely needs definition. There have been, and still are, outboard motors on the market that do not fit the accepted and usual pattern, however only that type of engine in most common use will be discussed here.

An outboard motor is technically known as a two stroke cycle engine, usually called two-cycle, which scavenges the cylinder by using the crankcase as the scavenging pump. It uses gasoline as fuel, and is lubricated by mixing oil in the gasoline. The carburetor is separated from the crankcase by valves. In the modern engine, these valves usually consist of commonly known leaf valves or reed valves. The charge to and from the combustion chamber is controlled through ports in the cylinder wall. Exhaust gases are conducted through suitable passages and discharged below water level. Cooling is accomplished by circulating water through cylinder jackets. This water is pumped from that in which the boat is operating.

USES OTHER THAN OUTBOARD MOTORS

While this article deals primarily with lubrica-

* Outboard Marine Corporation, Waukegan, Illinois

tion of outboard motors, it should be kept in mind that there are many other products using two-cycle engines having similar requirements for lubrication.

There are presently on the market many air-cooled engines using the two-cycle principle for chain saws, power lawn-mowers, generators, scooters, washing machines, and many other applications. Any lubricating development for outboard motors should include these applications in the study.

THEORY OF LUBRICATION OF TWO-CYCLE ENGINES

The fuel and oil used in two-cycle engines must be considered as a blend. It is not possible to consider the effects of one without considering effects of the other.

If a test is made on laboratory apparatus designed to show film strength, it will be found that the film strength of the gasoline and oil mixture is no different than that of gasoline without oil. This might be taken to indicate that gasoline without oil would operate satisfactorily in an engine. Since this is not the case, it is evident that the test either does not properly reproduce operating conditions or has not been interpreted correctly. It is felt that some process must be taking place inside the engine which distills out part of the gasoline leaving a residue of oil mixed with much less gasoline.

Some gasoline leaves the mixture due to vaporization at the carburetor and intake manifold. Since gasolines have a distillation curve variable with temperature, it must be assumed that the percentage of distillation of the fuel will vary directly with the temperature of the mating surfaces that form the bearing. As two bearing surfaces come together, the friction resulting from metal to metal contact develops heat causing a temperature rise. This temperature rise will distill the gasoline until a point is reached where the concentration of the lubricating oil in the mixture is high enough to provide a film with sufficient strength to separate the mating metal parts. If the lubricant which has been added to the gasoline lacks sufficient film strength at that temperature, seizure of the metal parts will result.

It would, therefore, seem important that the oil used in this type of lubrication system have sufficient hot film strength to allow distillation of gasoline to take place at a sufficiently elevated temperature to increase the proportions of oil to gasoline to form adequate lubrication.

It is obvious that this is a paradox. The temperature increase is necessary for distillation of the gasoline, while on the other hand, an increase in temperature will reduce film strength of the remaining oil.

WHY AN OUTBOARD MOTOR OIL?

In early days of the outboard motor industry, the entire source of lubricating oil for outboard motors was obtained from products developed for the automotive industry. At that time, lubricating oils were of the straight mineral type, without additives or detergents. During the evolution of additives, some of them had a detrimental effect on spark plug life in the two-cycle engine. As a result of this early experience, some erroneous attitudes grew up regarding the effects of detergents. There was a period when all outboard motor manufacturers specifically recommended against use of detergent oils. This attitude brought about the necessity of packaging a straight mineral oil which was labeled "Outboard Motor Lubricant."

Both detergent and non-detergent outboard oils are now on the market. Both types have their advantages and both can serve the industry if properly developed.

Now that "Outboard Motor Oils" have become established and are generally available, it is hoped that standard specifications can be established, based on performance of the lubricant in laboratory and in engine tests.

OILS AVAILABLE

Field complaints indicate that there is wide variation in the quality of oils available today. In a recent survey of one of the major outboard motor sales organizations, it was found that out of 638 dealers answering a questionnaire, there were 61 different brands of oil in use. With this large number of different brands, it is obvious that the engine manufacturer is in a poor position to test or pass comment on each individual brand.

It appears as though many of the outboard motor oils have had little or no actual development testing. Testing standards or specifications would do much to reduce or eliminate this undesirable situation.

REQUIREMENTS OF AN OUTBOARD MOTOR OIL

Following is an outline of the main properties that should be included in a good outboard motor oil. While these are not necessarily in the order of importance, they do represent major considerations in the development of a satisfactory lubricant:

1. Mixing Ability. The oil must mix readily in the fuel at all temperatures down to —10° F. It may seem rather unusual to have a —10° F temperature requirement. In developing an outboard motor lubricant, however, it must be considered in the wide range of field operation. It is necessary to keep in mind the hunter, the trapper, the commercial fisherman, and others who will use the waterways as long as they are free of ice. Admittedly, these users are relatively few in number, but it would not be fair to leave them out of our consideration. This would be depriving them of the use of a necessary product as a part of their sport or their business.

Applications such as chain saws operate more at low temperatures than at normal temperatures. A good

lubricant is most important in these light weight, high speed engines.

There are outboard oils on the market at the present time that at 0° F are practically solid in the container and it is difficult, if not impossible, to mix satisfactorily in gasoline.

2. Lubrication. The oil must lubricate in all normal ambient temperatures from —10° F upward. There are special applications where two-cycle engines have been used for military purposes where —65° F was a requirement, but these are the exception. The oil should have a high temperature film strength so as to prevent scuffing on heated bearing surfaces. These heated bearing surfaces may be in the connecting rod bearings, the main crankshaft bearings, or piston. All of these surfaces at one time or another may develop instantaneous high temperatures. If the oil lacks sufficient film strength at these temperatures, the result will be seizure and failure of the parts.

Over-cooling of the engine is also one of the major problems of lubrication. When operating in extremely cold water, such as exists in the Pacific Northwest, the engine will over-cool at low speeds, thereby forming moisture on cylinder walls. In this particular part of the country one of the great uses of outboard motors is for salmon fishing. In the process of fishing for salmon, the engine is idled for extended periods at minimum trolling speed. When operating at low speed, moisture that forms on the cylinder walls will displace the lubricant, as well as combine with some of the acids in the products of combustion. The resulting acid action will corrode the cylinder.

In addition to this problem, the low temperature of the mating surfaces does not distill off the gasoline, with the result that the mixture of gasoline and oil does not have sufficient film strength to separate the mating parts.

It is not known which of these two factors are the most important in cylinder wear.

In order to improve this situation, the outboard industry has recently initiated the use of thermostatic temperature control in the water jacket. It is expected this will go a long way toward rectifying the situation, since all tests conducted up to this point have indicated a substantial improvement.

3. Piston and ring deposits. When operating at full speed, the modern two-cycle outboard engine operates with a comparatively high piston temperature. It has been measured at approximately 350° F in the ring belt area. This temperature causes deposits in the ring groove and on the piston. An improved lubricant should aim towards reducing these deposits, keeping the rings free.

4. Combustion chamber deposits. Both the gasoline and the oil are responsible for the nature of deposits on the piston and in the combustion chamber. It is desirable to have these deposits break off in as nearly a powdered form as possible. As a powder they are much more easily scavenged through the exhaust system. If the deposits break off in larger parts, they tend to remain longer within the combustion chamber and may eventually deposit on the spark plug.

5. Spark plug deposits. Probably the most discussed and the most damaging of all detrimental effects of lubricants and fuel on the two-cycle engine is spark plug deposit. In the early days of outboard motor development, the wet, fouled spark plug was the most frequent occurrence. In the modern-day outboard motor, the deposits are dry and usually in the form of clinkers and flakes from the combustion chamber. Deposits collecting on the spark plugs have two effects. The most obvious is failure of the ignition. It is the most easily detected and does the least harm. While it may be annoying to the operator, it is not damaging to the engine.

The second and most critical effect of spark plug deposit is that which causes engine pre-ignition and deserves the greatest amount of study. It has been proven conclusively that certain types of deposits collecting on the spark plug can cause a wild, uncontrolled pre-ignition, resulting in substantial temperature rises and pressure rise within the cylinder. Temperature rise resulting from pre-ignition causes the piston to scuff, score, or burn.

In engines having a cylinder bore of less than 2½ inches, this effect does not seem to be as serious. Pre-ignition can go on for an extended period of time and the heat dissipation will seem to be adequate to keep piston temperature under control. In the larger bore engines, however, the problem mounts and it is only with considerable research and development that engine builders have been successful in making satisfactory power plants. It is in this area that perhaps the greatest improvements can be made in a lubricant, even though fuel may be the principal cause of trouble.

6. Exhaust port blocking. Port blocking varies considerably with engine size and temperature. Lubricant additives may be considered to reduce effects of a "dirty" fuel.

7. Corrosion. As shown earlier, gasoline and oil mixture is drawn through the carburetor into the crankcase and by-passed through the cylinder wall into the combustion chamber. When the engine is shut down for extended periods, the only protection internal parts have against corrosion is the residue left on the parts from the charge the last time the engine was operating. This residue must have sufficient anti-corrosion characteristics to prevent rusting of steel parts or corrosion of the non-ferrous parts until the engine is back in operation. On occasions, this idle period can be extensive. The very nature of the product, particularly in northern latitudes, requires that it have an extended lay-up period under drastically changing atmospheric conditions. It has been observed, in the servicing of motors, that anti-friction bearings will collect beads of water frequently and will have lines of rust in those areas where roller adjoins the races. (*Cont. on p. 359*)

Analysis of Films Formed by Radioactive E-P Additives

*by E. H. Loeser and S. B. Twiss,**

Relatively little use has been made of radioactive tracers in oil additives for the study of extreme pressure lubrication. This review of the literature is concerned with the analysis of films containing radioactive carbon-14 (in carboxyl group), radioactive phosphorus-32 and radioactive sulfur-35, which are formed from reactive oil additives on metal surfaces. The purpose of this review was to establish general principles of the mode of action of chemically reactive additives. The majority of the work reported dealt with static immersion of metal specimens in the radioactive oil; a few reports were concerned with film formation under dynamic test conditions. Activity of the additive appeared to be a function of concentration, temperature, pressure, nature of the wear surface and presence of other reactive oil additives. Determinations of radioactivity on the metal surface were generally made by means of Geiger-Muller counters and autoradiographs. The latter technique was particularly useful in dynamic tests to show the effect of pressure distribution on the wear surfaces.

INTRODUCTION

The principal use of radioactive tracer techniques in lubrication studies has been the utilization of radioactive metals in the measurement of wear and metal transfer. There have been numerous reviews of this work, and one reference (1) broadly covers the use of radioactive tracers in the petroleum industry. In recent years, however, the use of the chemical tracers has become increasingly important. This procedure involves tagging an atom of the lubricant or lubricant additive, and determining its concentration in the tightly adherent lubricant film formed on a metal surface.

The lubricant film may be produced either by simple immersion of a metal test strip, or by running the part in an engine, gear tester, or other bench tester with radioactive oil. The technique is particularly useful in the study of oil additives which chemically react with or are chemisorbed on the metal surface, and are not removed by solvent action.

Thus, it is possible to determine in a very precise manner how much of the radioactive element is combined with the metal in a surface film. In the case of a multiplicity of active elements, the end result of competitive reaction can be established by tagging each active element successively in the oil additive. Most of such studies are, of course, directed toward the establishment of the mechanism of some basic lubrication phenomena, such as the action of anti-corrosive agents or extreme-pressure lubricants.

Extensive, nonradiochemical investigations have made clear some of the more important characteristics of lubricant films formed by extreme-pressure additives. The films are very firmly bound to the base metal—they cannot be removed by any simple technique, such as by solvent treatment, mild abrasion, or thermal evaporation. The presence of chemical elements derived from the E-P additive, such as S, P, and Cl in the film can be shown by chemical analysis and, frequently, compounds of these elements with the metal can be detected by electron diffraction.

The stable E-P films are high melting and are removed by normal wear, but can be reformed as long as the supply of the E-P additive in the lubricant lasts and favorable reaction conditions are present. Ideally, E-P films are anti-welding, reduce scuffing, promote run-in, and are anti-wear in the sense that they reduce or prevent catastrophic wear. They do not necessarily reduce normal wear. It is with the analysis of such films that the present study is concerned.

Relatively little attention has been focused on E-P films, per se, from the radiochemical viewpoint, so a broader perspective has been taken. It is our purpose to attempt to establish some general principles in the use of chemical tracers, characteristics of the films formed, and conclusions as to the mode of action of chemically reactive additives.

FILMS FORMED FROM FATTY ACIDS

Although they are not capable of functioning as E-P additives, one class of compounds, long chain fatty acids, is of particular interest for two reasons:

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1. Fatty acids are capable of reacting with active metals such as iron, copper, lead, and zinc.
2. Some very excellent radio tracer work has been reported in the literature using these compounds. This review of earlier work is not exhaustive; only representative papers will be discussed.

The majority of work on fatty acid films is concerned with formation of the films under static conditions. Bowden and Moore (2) and Moore (3) reported experiments made to determine whether or not chemical reaction takes place between the adsorbed films of long chain alcohols, esters and fatty acids and the metal surfaces they lubricate. The additives were not tagged, rather, the metals were made radioactive.

By analyzing the wash solutions, the authors were able to determine whether a chemical film was formed and whether it could be removed by solvent extraction. The metal specimens were immersed in benzene solutions of stearic acid (1 percent), octadecyl alcohol (2 percent), or ethyl stearate, for five minutes, withdrawn and rinsed. The specimens were extracted with benzene in a Soxhlet extractor, and the extracts counted with a Geiger-Muller tube. The authors concluded that only physical adsorption occurs for the long-chain compounds on platinum or gold and for octadecyl alcohol on cadmium, zinc and copper as well. Zinc, cadmium and copper reacted chemically with the stearic acid solution, and to a lesser extent with ethyl stearate. The reaction did not cease with a monolayer, but, if sufficient material were present, thick films of soap were formed.

When chemical reaction occurred, the system exhibited good lubricating properties (low friction) at temperatures above the melting point of the fatty acid up to the softening point of the soap; if no reaction occurred, lubrication was limited to temperatures below the melting point of the fatty acid. Eisler (4), in an evaluation of the adsorption properties of rust preventive oils, immersed coupons of SAE 1020 steel in neutral oil containing radioactive stearic acid (tagged with C-14 in the carboxyl group). The coupons were drained, thoroughly cleaned in a vapor degreaser, and the surfaces counted with a Geiger-Muller tube. The amount of stearic acid adsorbed at room temperature increased with immersion time (1 to 20 minutes), when coupons were agitated as compared to static immersion, and with increased stearic acid content in the solution.

Gemant (5) immersed metal specimens in a hydrocarbon oil containing radioactive tridecanoic acid, C-14 in the carboxyl group. At certain intervals, the specimens were removed, washed in benzene and their activity determined with a thin window G-M tube. No deposits were formed on iron, aluminum or silver. Copper and zinc showed a relatively slow rate of film formation; lead was highly active.

Two investigators, concerned with the study of adsorption and desorption of stearic acid on solid surfaces, used the Langmuir-Blodgett technique of forming monolayers and multilayers on carefully cleaned surfaces. Beischer (6) heated the film to allow reaction, cooled and removed unreacted or physically absorbed stearic acid by a benzene rinse. The distribution of the reaction product on the surface was determined quantitatively by means of calibrated radioautographs. No chemical reaction occurred between platinum, vitreous silica, glass or mica and stearic acid in the temperature range between 25 and 100°C. Copper, cuprous oxide and cuprous sulfide did react, as shown in Figure 1. The reaction with cuprous sulfide was practically instantaneous, that with cuprous oxide the next most rapid, and that with copper requiring approximately two days to form a completed stearate film. Beischer termed this technique "radioactive staining" and found it particularly useful for determining active sites on a solid surface.

An excellent paper by Young (7) critically reviewed earlier studies of stearic acid films and described his investigations of films of radioactive stearic acid and metal stearates on copper, platinum and mica. The copper surface was probably oxidized in the air to form cuprous oxide. Autoradiographs proved the presence of chemisorbed layers on the surfaces; electron diffraction was used to indicate the structure of the adsorbed films.

Stability of the films was evaluated by thermal desorption and removal by mild abrasion or benzene extraction. A summary of some of Young's results are listed in Table 1.

On unreactive surfaces (platinum or mica) stearic acid or metal stearates were adsorbed physically and were relatively easily removed. On a reactive surface (copper) the stearic acid was converted in situ to copper stearate which was more difficult to remove. Young explained the greater stablity of his copper

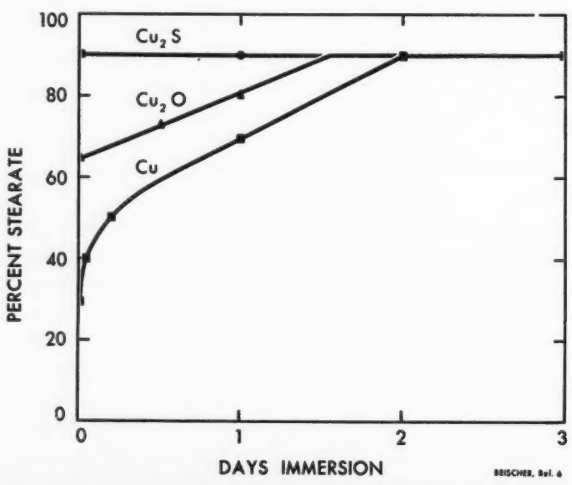

Figure 1. Reaction of stearic acid monolayer (C-14) on different substrates.

TABLE 1. Desorption of Long Chain Organic Compounds on Solid Surfaces

Surface	Property Studied	Adsorbed Material: Stearic Acid	Adsorbed Material: Copper Stearate
Copper (Surface probably Cu_2O)	1. Effect of heating at 81°C in air stream.	None removed	None removed
	2. Mild abrasion	None removed	None removed
	3. Hot benzene	Partially removed	Partially removed
	4. Electron diffraction	Weak soap pattern	No pattern
Platinum	1. Effect of heating at 81°C in air stream.	Partially removed	Partially removed
	2. Mild abrasion	None removed	None removed
	3. Hot benzene	All removed	All removed
	4. Electron diffraction	Free acid pattern	Soap pattern
Mica	1. Effect of heating at 81°C in air stream.	All removed	All removed
	2. Mild abrasion	Partially removed	Partially removed
	3. Hot benzene	All removed	All removed

stearate films formed in situ, as compared to the stearate films studied by Bowden and Moore (2), as due to the formation of a monostearate with one valence of the copper combined with the oxide film. He postulated the formation of distearates in the presence of an excess of stearic acid. The distearates could be removed by benzene extraction.

FILMS CONTAINING RADIOACTIVE PHOSPHORUS AND SULFUR

The work reported in the literature on compounds containing radioactive phosphorus and sulfur, although not specifically concerned with extreme pressure lubrication, gives results that are of great significance to an understanding of E-P film formation. One of the earliest works in this field was that of Clark, Gallo and Lincoln (8) who investigated films formed from an oxidation inhibitor, sulfurized olefin derived from petroleum wax, containing S-35.

The technique involved immersion of seven different types of commercial metal bearings and glass specimens in sulfurized olefin contained in mineral oil, and rinsing the specimens with benzene and carbon disulfide following immersion. The amount of film formed, determined with a G-M counter, was dependent on the chemical composition of the surface and increased linearly with time for the first 20 hours and then leveled off.

For a typical bearing composition, both the rate of film formation and the amount of deposit formed at 25°C were considerably less than at 88°C. The authors suggest that the adsorbed organic molecules may form a loose molecular compound on the metal or a polymerized film, sufficiently adherent to resist solvent action.

Some excellent Russian work was reported by Zaslavskii (9,10) who studied the film formation of anti-corrosive agents such as "sulfurated oil" additive, tagged with S-35, and triphenyl phosphate, tagged with P-32. The method of specimen handling differed slightly from other immersion procedures in that the metal plates (lead, copper, lead bronze and steel) were mechanically cycled in and out of the heated oil which contained the tagged additive. Runs were made in the temperature range, 90 to 220°C.

Both additives were used in concentrations of 0.5 percent in mineral oil. After a number of cycles, the plates were washed with benzene and the surface radioactivity determined with a G-M counter. For each temperature, the film formed increased to a value characteristic of each metal and then leveled off.

With triphenyl phosphite additive, increased temperature caused a sharp increase in the *rate* of film formation; however, the *weight* of film formed on steel or lead bronze decreased, while that on lead went through a maximum at 140°C, as shown in Figure 2. Analogous results were obtained with the "sulfurated oil." The authors concluded that the films were formed by chemical interaction of sulfur and phosphorous with the metal, sulfur reacting most strongly with copper and phosphorous most strongly with lead. Sulfur reacted negligibly with steel, and only above 110°C, whereas phosphorus reacted more intensively with steel at lower temperatures.

Of special interest is the technique used to determine the depth of penetration of the sulfur from the "sulfurated oil" below the surface of lead bronze and lead. Microlayers of metal were successively removed from the plates and radioactivity of these underlying surfaces measured, with the results shown in Figure 3. Interestingly, the anticorrosive effect of the additives for the different metals appeared to be in direct proportion to the extent of film formation.

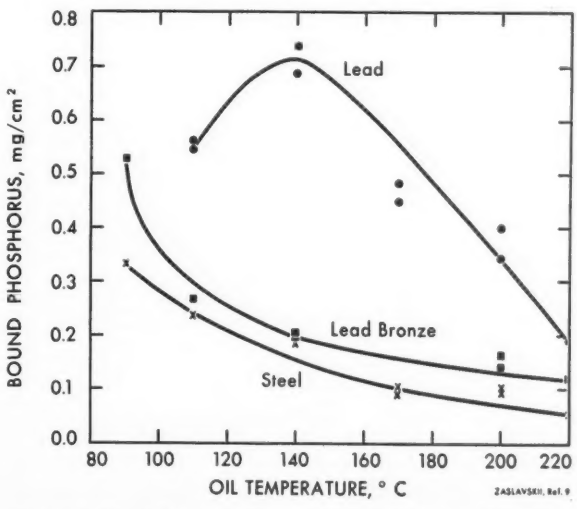

Figure 2. Effect of temperature on film formation (P-32) from triphenyl phosphite.

Vinogradov et al (11) investigated the action on steel and copper of tributyl trithiophosphite, containing P-32 or S-35, tributyl phophate, and elemental sulfur, S-35. The additives were used in the concentration of 0.1 mole per liter in a naphthene-paraffin oil. After each step of the immersion test, the samples were washed with gasoline and counted. Figure 4 shows that the amount of phosphorus bound on the surface of steel and the rate of reaction both increased with temperature (in the range of 20 to 150°C); at the lower temperatures, the rate of film formation leveled off. Phosphorus was bound much more intensively than sulfur with steel, and the authors concluded that the formation of phosphide prevents the formation of sulfide film on steel. The binding of phosphorus on copper and steel were of approximately the same intensity.

With elevation of temperature, the amount of phosphorus or sulfur on the steel surface increased, reaching a maximum at 160°C, after which it declined. The binding of sulfur on copper increased with increased temperature to a greater extent than it did on steel. At all temperatures, the amount of sulfur on copper was greater than the amount of phosphorus, and furthermore this amount is much greater (by several orders of magnitude) than in the case of steel.

One of the most important papers reviewed, because it involves the study of an E-P additive, dibenzyl disulfide, containing S-35, is that of Borsoff and Wagner (12). These authors were concerned with the investigation of 0.5 percent sulfur in SAE 30 mineral oil in the lubrication of gears. Both static and dynamic tests were run, the dynamic in a spur gear machine at 3000 rpm. SAE 3312 steel, case hardened to 62 R_c and 20-microinch finish, was used. The densities of a series of autoradiographs, used as calibration standards, were correlated with radioactivity as determined with a G-M counter. Following static or dynamic tests, specimens were washed in solvent and

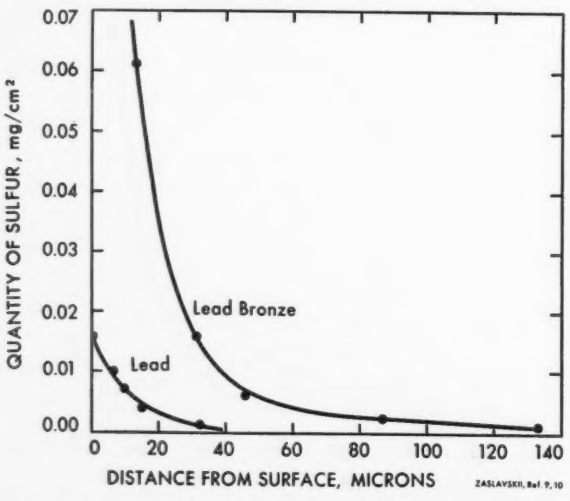

Figure 3. Penetration of S-35 from "sulfurated oil" below surface at 140°C.

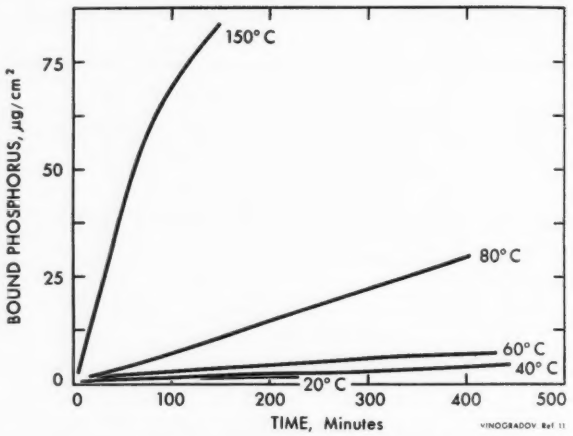

Figure 4. Rate of film formation (P-32) from tributyl trithiophosphate on steel at various temperatures.

autoradiographs taken. On immersion, the reaction of steel strips with the additive appeared to be autocatalytic, that is, increased with time.

The amount of sulfur contained in the film increased markedly with temperature, which appears to correlate with the observation that the thickness of films on the gear teeth increased with increasing load. At each load, in the dynamic tests, a steady-state thickness of the film was reached fairly rapidly, indicating that rate of formation of the film and removal by abrasion were approximately equal. To check this conclusion, for the test performed with three hours duration at each load, the scale load was decreased several times to five pounds. Each such decrease in load was accompanied by a decrease in thickness of the film, as shown in Figure 5.

Little formation of film was observed on the non-operative parts of the gear where contact pressure was low or non-existent. The maximum thickness of the E-P film was calculated to be 1.2×10^{-6} inches, or about 100 monolayers of sulfide film.

Furey and Kunc (13) immersed steel specimens in solutions of zinc dialkyl dithiophosphate (containing Zn-65) in hexane for ten minutes at room temperature. It was calculated that the zinc remaining on the surface after repeated rinses in various organic solvents was equivalent to over 100 molecular layers of the additive. Experiments with blends of this radioactive additive in white oil showed that retention of zinc by steel surfaces increased with time, concentration and temperature. An increase of temperature from 70 to 300°F caused a 15-fold increase in the amount of zinc picked up by the steel. An increase in concentration from 0.01 to 1.0 percent by weight increased zinc in the surface film by a factor of 12 to 20.

The authors concluded that the retention of zinc was probably caused by a chemical reaction, but they found no correlation between the quantity of zinc retained by steel and the wear of valve lifters in oil containing this additive (in non-radioactive form). This may indicate that the zinc part of the additive is

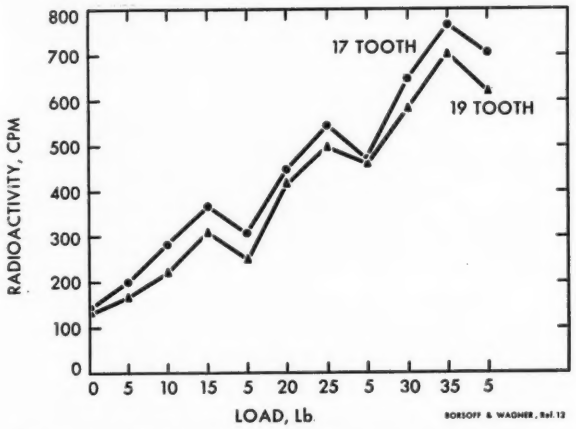

Figure 5. Effect of load on film formation (S-35) from dibenzyl disulfide on steel spur gears.

not important in wear reduction, or it may mean that static immersion results give no significant idea of the processes occurring under dynamic conditions.

An important piece of work by Weinstein and Kalinsky (14) was concerned with the determination of adsorption properties of rust inhibitors used in marine turbine oils. One rust inhibitor (A) contained P-32; the other rust inhibitor was a dibasic acid (B) and contained C-14 in the carboxyl group. The base stock turbine oil contained one or both of the rust inhibitors, plus non-radioactive oxidation inhibitors and an anti-foaming agent.

Static tests were run at temperatures of 25, 70 and 135°C, and dynamic tests in a gear reducer. The primary metal concerned was steel, although immersion tests were also carried out with nickel-copper (Monel), admiralty brass, copper, and babbitt metals. Generally, the specimens were counted after a temperature treatment and extraction with boiling benzene. For both additives A and B, the rate of adsorption was greatest at the initial period of contact between oil and metal, reaching maximum equilibrium values in three to eight days. Thereafter, adsorption of A and B at the lower temperatures remained constant, but for B at 135°C, the level of adsorption decreased. Adsorption rates were strongly temperature dependent, particularly during the early period of contact.

The presence of additive B had no influence on the adsorption of A on steel, copper, brass and admiralty metals, but caused a decrease in adsorption of A on nickel-copper and babbitt. Figure 6 shows the effect of temperature on rate of adsorption of A on steel surfaces both with and without additive B. The presence of additive A did not affect the chemisorption of B at 25°C, but decreased adsorption of B on steel surfaces at 70° and at 135°C. See Figure 7. The rate of adsorption of both A and B was directly proportional to the volume and concentration of additive in oil per unit area of steel. Analysis indicated the formation of a chemically adsorbed, non-phosphide, inorganic FE-P compound from additive A.

Similarly, the authors concluded that the film formed from additive B was a soap produced by reaction of the dibasic acid with iron, although this soap film could be partially removed by heating at temperatures of 75° and 135°C. Both additives A and B were partially depleted by running in the gear reducer, either under dry or moist conditions; a considerable amount of radioactive additive was found to be associated with the wear particles.

Finally, autoradiographs of the gears showed that both additives adhered principally to the rough, nonwearing surfaces. Portions of the gear subject to wear were relatively free from radioactive deposits.

SUMMARY AND CONCLUSIONS

Relatively little use has been made of radioactive tracers in oil additives for the study of extreme pressure lubrication. This is unfortunate, as it appears to be one of the most potent tools for analyzing E-P films and determining their mechanism of formation

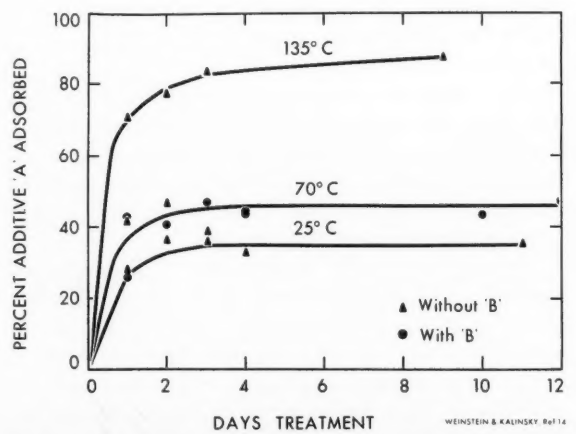

Figure 6. Rate of film formation (P-32) from additive A on steel at different temperatures.

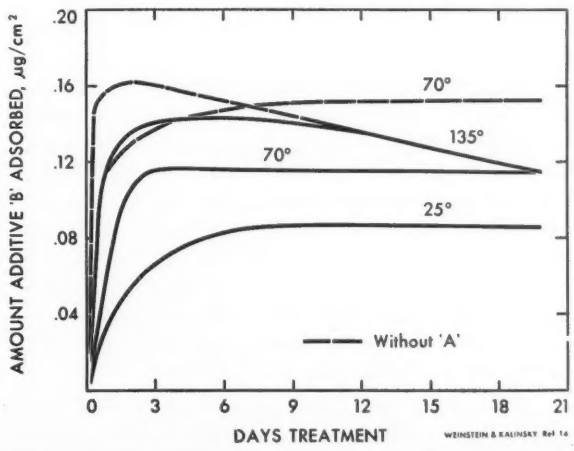

Figure 7. Rate of film formation (C-14) from fatty acid additive B on steel at different temperatures.

and removal under dynamic test conditions. The use of radioactivated metal surfaces, although useful for metal wear measurements, is less productive in the study of additive action. By determining the amount of metal removed by the additive reaction, something can be learned about the corrosiveness or wear reduction properties of a lubricant—but nothing can be learned about the lubricating film left on the surface. The analysis of this film by the use of radioactive tracers is a very direct and sensitive method, capable of determining concentrations as low as 10^{-9} to 10^{-12} grams per square centimeter.

The most generally used technique by investigators studying film formation was simple immersion of solid strip specimens in the radioactive oil, with or without agitation.

This technique has the advantages of ease of operation, good temperature control, and simplicity of counting. However, because the temperatures at wear surfaces under dynamic conditions are much higher than the oil temperature, it is doubtful whether immersion is capable of giving the types of reacted films formed under dynamic conditions. Because of the instability of the oils and oil additives at high temperatures, it would be difficult or impossible to simulate the temperatures at contact areas in immersion tests. Conclusions made on the basis of immersion tests, although quite useful for screening oil additives, should be checked by running dynamic tests.

Following immersion or dynamic testing, solvent extraction of the metal surface was generally used to remove the excess oil and physically adsorbed films. It is generally concluded that the film remaining on the surface after solvent washing or extraction is chemically adsorbed or reacted to form an adherent film.

Under certain conditions (moderate temperature) this may be a satisfactory criterion for chemical absorption, but under other conditions (high temperature), polymerization or varnish formation may occur which could yield films insoluble in the solvent but not chemically adsorbed. Loosely held films, even though formed by chemical reaction, are generally removed by solvent washing.

Heating, evacuation and mild abrasion has been used similarly to determine the adherence of adsorbed films. Most of these techniques are capable of partially removing physically adsorbed films, but none of them apparently affect chemisorbed additives except in the case of carboxylic acid salts. Heating can cause decarboxylization, resulting in a loss of radioactive C-14. In other cases, heating apparently fosters chemical reaction of the adsorbed film with an active metal surface and, of course, heating would accelerate polymerization of certain oils.

For the flat specimens generally used in immersion tests, counting with a Geiger-Muller counter gives quantitative results. For irregularly-shaped surfaces, although the G-M counter has been used, it is doubtful whether results of the same accuracy are obtained. For such surfaces, autoradiographs, produced by exposure of X-ray film, give the most satisfactory results.

On dynamic wear surfaces, autoradiographs have the distinct advantage that they give a pattern of the distribution of radioactive atoms, which is probably a function of contact pressure. Certain investigators calibrated the density of their autoradiographs from standard flat specimens with the G-M counter.

In the static immersion test, general behavior of additives with metals involved a rapid initial adsorption, followed by decreasing rate until the amount of adsorbed additive became practically constant with time. In general, many hours are required to achieve this steady-state condition. The effect of temperature was to increase markedly the rate of film formation; in most cases, the amount of film formed also increased. In a few cases, increase in temperature decreased the amount of adsorbed film and/or also caused a maximum to appear in the amount-vs-time curve.

Certain unexpected effects occurring at these high temperatures might be caused by oil breakdown, since very little attention was paid this factor by most investigators. In dynamic tests, a similar pattern of film formation was observed: the amount of adsorbed film increased with time of run and with temperature (or load). In the case of one investigator, the steady-state or equilibrium film formation appeared to occur in a much shorter period of time than was required under static immersion conditions.

In those few reports where dynamic tests were reported, conflicting results were obtained. On the basis of tests with a sulfur containing, extreme-pressure additive, the highest concentration of active atoms was found on the high pressure areas of spur gears. However, in tests of rust inhibitors containing phosphorus and carboxylic acid groups, least radioactivity was found on the high wear areas; maximum concentration of both P-32 and C-14 was obtained on the rough, noncontacting areas of gears. This apparent conflict may be resolved when abrasive wear and/or the action of water (in marine turbine oils) is taken into account.

The observed film thickness is dependent on the rate of film formation and the rate of its removal. The latter process will be accelerated by abrasion, and corrosion and leaching by water, which if they predominate, can give the apparent result that the active film is either absent or very thin.

Where calculations were made of the thickness of adsorbed films, these ranged up to 100 monolayers. Since this is much thicker than has generally been assumed for chemisorbed films, other factors are probably involved in the formation of such multilayers.

Most of these film thicknesses were calculated on the basis of the geometric surface area, rather than the true area of the metal, so that considerable error

exists in statements of "thickness of film in monolayers." If the oil additive breaks down at the surface, leaving the radioactive atom combined with the metal, the assumed size of the adsorbed molecule would be much too large.

Finally, the possibility exists, particularly at elevated temperatures, that there is a chemical reaction between active groups in the oil breakdown products, thus binding the multilayers together by polymerization.

The effect of surface roughness, since it is generally unknown, can be very important in the analysis of additive films. It was pointed out above that surface roughness could introduce errors of several orders of magnitude in calculating the number of layers in an adsorbed film. In addition, one observation that S-35 could penetrate into a lead or lead-bronze surface may indicate only that the additive has penetrated to the bottom of the crevices or valleys in a relatively rough surface. Further work is required to indicate the true cross-section structure of additive films.

Probably one of the most important observations resulting from this review is the specificity of additives for different metal surfaces. It was observed by several workers that sulfur is adsorbed more rapidly on copper surfaces and copper bearing alloys and phosphorus on steel or iron alloys. In addition, polar films such as oxides or sulfides apparently react much more rapidly with fatty acids than reduced surfaces. A more complete understanding of this specificity of additives for particular metals could lead to improved selection of lubricants for solid film formation.

The observation that the chemisorption of one additive can inhibit the reaction of a second additive is also very important. This is indicative of competitive reaction of additives at the metal surface resulting in the formation of films of different composition depending upon the temperature and other reaction conditions. The proper control of such competitive reaction could result in combinations of additives which give better lubrication over a wider range of conditions than are presently available.

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Rust Preventives

E. J. Colerick *

Records of metal corrosion can be traced back to the lower neolithic age or about 1400 B.C.; however, little concern was felt by this attack on our metallic wealth as rust was accepted as a necessary evil. Later the principle of protecting surfaces which are susceptible to rusting and corrosion by the application of an inert film was realized and has now been applied many centuries. The first coatings or films used as rust-preventives were such materials as animal oils and fats such as tallow, lard oil, fish oils and sperm oils. Some of these were wonderful rust preventives and are still in use today. The research and development of petroleum base rust preventives, as they are known today, did not gain momentum until the late 1930's which followed by World War II gave great impetus to this young industry.

A brief review of a recent study on the cost of corrosion to U. S. industry will illustrate that we have only scratched the surface in our attempt to determine the mechanism and corrective means of preventing and retarding corrosion.

It has been conservatively estimated that the annual cost of corrosion in the USA is in excess of six billions of dollars, i.e., one of every 50 tons of iron and steel annually reverts to iron oxide.

U. S. railroads' annual corrosion cost is over 500 million. Cables, foundations and pipe suffer over 1 billion dollar damage annually from contact with the ground. Hot water tank replacement through corrosion cost home owners over 225 million dollars. The U. S. Navy has estimated a loss of over 100 million annually due to metal corrosion. SAE claim corrosion a major factor in the annual junking of 3 million automobiles.

What is metal corrosion or rusting? Simply stated, it is an electrochemical action by which most metals try to revert or return to their natural form, namely oxides.

Although there are many conditions which cause corrosion, the prime cause and perhaps the most difficult to understand is that attributable to moisture and air. These two substances must be excluded to avoid electrochemical corrosion. When two metals are in contact with each other in a solution, water or chemical, an electric current is formed that causes the corrosion of the more chemically active of the two metals. For this reason, when bi-metal fabrication is necessary, Table 1 should be referred to, for when using two or more different metals, the selection of these metals is of extreme importance in order to avoid metals differing considerably in electrode potential.

TABLE 1. GALVANIC SERIES
(Related behavior of metals and alloys in natural electrolytes)

CATHODIC (+)	
↑ Stainless Steel (passive)	Chromium Stainless Steel (active)
Monel Metal	Cast Iron
Silver Solder	Wrought Iron
Nickel (passive)	Mild Steel
Gunmetal	Cadmium
Cupro Nickel	Aluminum Alloys
Copper	Aluminum
Brass	Galvanized Wrought Iron
Aluminum Bronze	Galvanized Steel
Nickel (active)	Zinc
Naval Bronze	Magnesium Alloys
Manganese Bronze	Magnesium
Tin	
Lead	
Stainless Steel (active)	
Lead Tin Solder	
	↓ ANODIC (−)

Table 1 gives a good indication of the couples to be avoided. A large area of cathodic (+) metal in contact with a small area of a anodic (−) metal of widely different electrode potential such as monel metal and mild steel would cause a rapid electrochemical attack on the mild steel in the presence of an electrolyte.

* Industrial Products Department, Shell Oil Company, New York, N. Y.

Using the above principle, research developed the sacrificial anode which today is used to protect everything from the household hot water heater to the hulls of ships. These anodes are usually made of magnesium, a metal, shown in Table 1, which is high in the galvanic series. These magnesium anodes serve to protect less chemically active metals such as iron and steel from electro-chemical corrosion. The anodes suffer the damage and are replaced when deterioration has reached a point where they can no longer protect the other metal. Oil-immersed rectifiers are also used in the protection of pipe lines and underground cables. Rectifiers generate their own weak current which principle is very similar to the sacrificial anode.

In addition to the sacrificial anode and the rectifier, industry employs many other methods to retard corrosion.

METALLIC COATINGS

Metallic coatings such as aluminum, tin, nickel, zinc and copper are applied by plating, spraying and dipping.

NON-METALLIC COATINGS

Non-metallic coatings consist of paints, resins, plastics, petroleum-base materials, volatile corrosion inhibitors and chemicals. Paint is in first place as a protector against corrosion for over half of all metal paint sold is for protective purposes.

During 1956, 24,800,000 gallons of resin-plastic type rust preventives were sold to industry. These included such resins as urea, melamine, styrene, vinyl chloride, phenolic and acrylic polyesters.

Chemical preservatives such as urea plus sodium nitrite, dicyclohexylamine and di-isopropylamine nitrites which are commonly known as volatile organic amine nitrites or vapor-phase inhibitors are slowly gaining acceptance, particularly in the packaging industry.

PETROLEUM BASE RUST PREVENTIVES

It is still a fact, that, for temporary or long-term protection, oil type rust preventives are the cheapest method of protection. Millions of gallons will be used annually by the government agencies and industry, particularly in the steel and automotive industries although we anticipate that the use of chemicals, resins, and plastics will also increase, replacing certain oil-type rust preventives. Refined petroleum oils are excellent carriers for effective rust prevention additives. These oils are low in cost, non-volatile, moderately good solvents and have lubricating properties where they are required.

As previously stated, it was not until late in 1930 that a great concerted research effort was made by government and private industry to develop improved oil-type rust preventives. Overnight, because of the war, the government required huge quantities of these types of rust preventives. The leader in the development of protective coatings from petroleum and petrochemicals has been and continues to be the Department of Defense. Under their direction, rust preventives are being developed and evaluated at Rock Island Arsenal, Wright-Patterson Air Force Base, Naval Air Command, and the U. S. Naval Engineering Experimental Station.

The Government is now in the process of consolidating their oil base rust preventive specifications into five groups similar to the group classification used by many suppliers; namely:

1. Solvent cut-back fluids
2. Hot-dip compounds
3. Petroleum oil plus additives
4. Internal Combustion Engine Preservatives
5. Chemical Preservatives

When this consolidation is completed, most government specifications for rust preventives will fall into one of the above groups. New specifications for groups 1 and 2 have been completed and are known as MIL-C-11796A and MIL-C-16173A. The former specification is divided into four classes which are hot application compounds which vary from soft to hard films. The latter specification also has four classes all of which are cold applied solvent cut-back preservatives also varying from an impervious hard film to a soft film, which readily displaces moisture.

Solvent Cut-back Fluids

In general, these products consist of low-viscosity oils or rather viscous oils plus a volatile solvent. Blended with the mineral oil are usually several surface-active additives. The solvent diluent is usually mineral spirits, or kerosene, however for special applications highly aromatic solvents are used. Trichloroethylene can also be used where a non-flammable solvent is required. The solvent acting as a vehicle evaporates leaving a thin transparent oil or waxy film of desired thickness. Fluids of this type are easy to apply by dip, spray, swab or brush. They are designed specifically for the indoor protection of sheet steel, highly machined surfaces, small parts under relatively mild conditions of shelf storage, package shipment or interprocess protection. Special water displacing and finger print neutralizing characteristics can be built into these fluids. These characteristics are mandatory in fluids protecting parts which are wet with water or soluble oil from machining operations as well as parts which are stained by finger prints under high humidity conditions. These films are easily removed by wiping, degreasing, or hot water washing.

Hot-dip Compounds

Hot-dip compounds are generally hard tough coatings. These rust preventives most closely approach the paints in physical characteristics. Hot-dip compounds differ from paints in being removable: they

have little or no decorative value, are opaque, and less expensive than paint. However, the film provided is not self sealing, and a break in the surface coating can result in severe under-surface attack. Hard film coatings are recommended for protection in out-door unsheltered exposure. Products which give this type of film consist of non-volatile bases dissolved or suspended in volatile solvents. The solvents are of the paint-thinner type, mineral spirits, or aromatic extracts. The noon-volatile portion is generally a special high melting point, tough elastic asphalt. Should a clear coating be required, the asphalt can be replaced with a material such as ester gum or a refined petroleum resin. The principal disadvantage of hard coatings is the difficulty encountered in removing the film. An aromatic solvent is necessary for removal; however, these films do provide excellent long-term protection in outdoor, unsheltered storage.

Petroleum Oil Plus Additives

Oil-type preservatives in this group include the non-drying, non-setting type of protective films. This group includes various viscosities of oil plus polar additives; however, the low viscosity oils are most versatile and popular. They are easy to apply and remove; the films are clear and odorless, and are self-mending if ruptured. It is unfortunate that the degree of protection obtainable with these films is limited for if it were possible to obtain long duration protection with oils of this category, they would largely replace most of the other types.

The humidity cabinet life of a straight 100 second mineral oil is approximately three to four hours. But with the incorporation of selective additives this humidity cabinet life can be increased to over 1,000 hours. These additives include the organic fatty acids, their salts and esters, and various salts of petroleum sulfonic acids.

Oil plus additive types of films which could be recommended for outdoor storage have not yet been developed, but they are excellent for indoor shelf storage or inter-process protection.

Internal Combustion Engine Preservatives

For years the government and industry have used millions of gallons of internal combustion engine preservatives. Probably the most widely known of all U. S. Government Specifications is MIL-L-21260 Lubricating Oil Internal Combustion Engine Preservative which covers three SAE grades, namely 10, 30 and 50. The need and advantages of special internal combustion engine preservatives became evident when it was realized that oils meeting MIL-L-2104A could not provide the protection required for engine storage or extended periods of shut-down.

MIL-L-21260 oils utilize high viscosity index, solvent extracted base oils plus polar additives and with a neutralizer for the acidic products of combustion. Oils of this type are used for the protection of engines to be stored or shipped. Using these oils which lubricate as well as protect, engines can be operated safely but for short periods of time only.

The advent of the highly alkaline heavy-duty engine oils and the upgrading of proprietary brand engine oils by the petroleum industry over the past five years have resulted in the existence of high additive-level oils which either equal or exceed the humidity cabinet life of MIL-L-21260 approved oils. Last year one of the big three automotive producers, who customarily used over 3,000,000 gallons annually of a SAE 10 drive-away oil meeting MIL-L-21260, found it advantageous to change the drive-away oil specification to one conforming to MIL-L-2104A but requiring the rust protection comparable to the MIL-L-21260 oils.

Today indications point to the future abandonment of U. S. Government Specification MIL-L-21260 when all proprietary brand engine oils give equal or superior protection and have a humidity cabinet life exceeding 500 hours. Engine operation for a normal period before an oil change is the principal advantage over MIL-L-21260 type oils. The action of some high additive level proprietary engine oils is similar to that of lubricating oils containing rust inhibitors such as turbine and hydraulic oils which displace water from surfaces bathed by the oil in continuously circulating oil systems.

Chemical Preservatives

A variety of chemicals have been introduced in recent years. One of the important ones is hydrazine which has been successfully used to condition feed water for boilers. This clear colorless liquid reacts with oxygen to form nitrogen and water. It is claimed that one pound of hydrazine will remove one pound of oxygen.

Of all chemical preservatives, the volatile corrosion inhibitors appear to be most popular and effective. This group has been given the name of V. C. I. by the joint industry committee which has now been adopted by most people in the industry. These products consist of volatile organic amine nitrites and related compounds such as *urea plus sodium nitrite, dicyclohexylamine nitrite* and *di-isopropylamine nitrite*. As can be noted, these products contain the nitrite ion which is really the part that inhibits corrosion. The vapor pressure of these compounds is related to their molecular weight, and is sufficient to cause them to sublime slowly, producing vapors which inhibit corrosion even in the presence of moisture and oxygen. The vapor condenses on the metal surface where the nitrite ion is oriented. This action is unique to this class of rust preventives. The other classes which have been discussed, either displace or exclude oxygen or moisture from the surfaces to be protected.

The use of vapors for protection against corrosion has possibilities of protecting remote areas which heretofore were almost impossible to protect. The va-

pors protect with great ease and in many instances offer economic advantages over conventionel methods. They also involve no removal or cleaning problems.

Nevertheless, V. C. I. cannot be considered as a cure-all for all corrosion problems. It should be considered as a forward step in the fight against corrosion, and only through intelligent application will its full advantages be realized.

V. C. I. may be applied directly in crystalline form, coated on paper, or used in a solution, or as in the latest innovation, as aerosol bomb. The type of protection desired will govern the method of application. For example, upper cylinders of internal combustion engines would best be protected with the crystals; while shipments of riffles would best be protected with coated paper and boxes of small parts would best be protected by both crystals and paper.

In any of the methods previously mentioned, the powder sublimes and the protecting vapor is transported by convection and diffusion to all surfaces of the metal where it condenses, giving a minutely thin layer of the crystals. In the presence of even minute quantities of moisture, these crystals dissolve, yielding the nitrite ion in the condensed or absorbed moisture. As can be seen, this is not to be compared to a desiccant-type protective, such as silica gel, since the V. C. I. does not absorb the moisture but merely acts in its presence.

ADVANTAGES OF VOLATILE CORROSION INHIBITORS

1. They provide years of economical protection under severe conditions of humidity and temperatures.
2. If rusting has already begun, V. C. I. will arrest the present rusting and stop any further corrosion.
3. There is no grease, oil or "gunk" to remove prior to use of the protected unit.
4. Solutions of V. C. I. in distilled water in concentrations of 0.01 percent protect immersed steel parts from rusting.
5. The labor of applying rust preventive coating on the steel is eliminated since the V. C. I. vapors travel and apply themselves to all portions of a packaged article within approximately 12 inches from their source.
6. Packages do not need to be tightly sealed.
7. The presence of an oil or other preservative film on the part to be protected does not impair protection afforded by V. C. I. vapors.
8. Articles which are in a V. C. I. package may be removed, examined and replaced without destroying the protective action.
9. V. C. I. is harmless to handle. No instances have been found of skin reaction; however, the chemical is slightly toxic if taken by mouth, though no more so than sodium nitrite which is used as a preservative for canned meat.

LIMITATIONS OF VOLATILE CORROSION INHIBITORS

1. V. C. I. has no detrimental effect on most nonferrous metals but offers no outstanding advantages in preventing corrosion on them.
2. V. C. I. decomposes to a noticeable degree at temperatures above 150°F-160°F. At 225°F., it decomposed quite rapidly.
3. V. C. I. is decomposed by acids; however, a new V. C. I. containing an organic basic neutralizer has been developed and has been found effective in the presence of acidic conditions such as the combustion chambers of internal combustion engines.

EFFECTIVENESS OF V.C.I.

The period of protection of V. C. I. is dependent on several factors, namely, ambient temperature, nature of outer barrier, rate of circulation of air through and around the package, and the rate of leaching of the condensed crystals from the surface of the metal. A vapor-tight package containing three grams of V. C. I. per cubic foot of volumetric contents stored at an ambient temperature of 70°F. could be expected to provide complete protection against rust for a period in excess of 15 years. If the ambient temperature were raised to 110°F., the life expectancy of the V. C. I. would be approximately one year. To estimate coverage, industry uses a "rule of thumb" of three grams per cubic foot or two grams per sq. foot. Before discussing "cleaning," it should be emphasized that the proper application of the rust preventive is even more important than the choice. It is important to follow the prescribed procedures, such as the Army method for engine preservation and packaging specifications.

TYPES OF CLEANING METHODS USED PRIOR TO APPLICATION

It is impossible to overemphasize the necessity for thorough cleaning. The time and care taken in selecting a proper rust preventive is wasted when the product is applied over a dirty or contaminated surface. In order to obtain maximum or even reasonable benefits from various preservative coatings, there should be no contamination whatever remaining on the surface to be coated. The contaminants to be removed include dust, dirt, moisture, perspiration residue, metal chips, cutting, cooling, drawing, and polishing compounds, rust and scale, welding or soldering fluxes, chemical mists, residues from heat treating processes, pickling acids and etching solutions. Where moisture or perspiration residues are the only contaminants present, water displacing and perspiration neutralizing fluids can be used to effectively clean and protect in a single application.

Four types of cleaning are utilized before applying protective coating i.e., mechanical, chemical, solvent and steam cleaning.

When the surfaces are already rusted or covered with scale or dirt mechanical cleaning is used, usually scraping, with a wire brush or blasting with shot or sand.

Chemical cleaning employs a 200°F. mild alkali bath or the use of many chemicals such as silicates, phosphates, borates and carbonates. Chemical cleaning is not used for highly polished surfaces or for use on aluminum, zinc, or magnesium.

Solvent cleaning is used to remove oil, grease, moisture and perspiration deposits. Mineral spirits, or alcohol are most commonly employed.

For impact removal of contaminants, steam cleaning is very effective. Hot water rinsing is also used although thorough drying is mandatory before applying the preservative. Steam cleaning is superior in removing heat treatment salt-residues and fluxes.

LABORATORY EVALUATION TESTS

In conclusion it might be well to mention briefly the laboratory tests used to evaluate protective coatings. Although all laboratory tests are accelerated procedures, they do give a degree of correlation with actual service life.

1. *HUMIDITY CABINET TEST*

In the humidity cabinet test, metal panels with uniformly prepared surfaces are coated with a rust preventive and placed in a special cabinet through which air passes at a uniform rate. This air is maintained at 100 percent relative humidity, heated to 100°F and directed through the cabinet against bafle plates which insure uniform air distribution. Coatings comparable in purpose and consistency are placed on special test panels, and the measure of quality is the number of hours elapsed before initial corrosion takes place, as determined by visual examination of the surface.

The humidity cabinet test is a good indication of the merit of products used for indoor or sheltered outdoor storage where humidity and temperature variations are the main corrosive influences.

2. *SALT SPRAY TEST*

For the salt spray test a specially constructed cabinet is used. Coated panels are hung vertically and subjected to a spray consisting of either 4 or 20 percent salt solution in water. This spray is highly atomized by impingement upon a baffle plate and then passes over the panels. The salt spray simulates in an accelerated manner the severe conditions found near the seashore or when shipment is made by boat.

3. *WEATHEROMETER*

The weatherometer is a circular metal box containing a powerful ultra-violet light to simulate sunlight and a spray section to simulate rain. The treated panels revolve slowly around a circular track inside the box and are alternately exposed to artificial sunlight and rain. Fifty or sixty days in this cabinet is generally considered equivalent to one year's outdoor exposure.

Other tests include the use of contact angles, static water drop test, and several tests to indicate such properties as ease of removal, separation tendencies, drying time, film thickness and compatibility with other lubricants.

The common faults in testing rust preventives are the use of tests which are unnecessarily severe or neglect to cover some corrosive factor which does occur in actual use. Actual service results are the final check and are always to be preferred.

GUIDE TO AVAILABLE PUBLICATIONS

INTERPRETING SERVICE DAMAGE IN ROLLING TYPE BEARINGS

Manual on ball and roller bearing damage includes drawings, tables and photos to aid in classifying and identifying causes of bearing damage. $1.00. Foreign $2.00

LUBRICATION ENGINEERING DECENNIAL INDEX

Subject and Author Indexes list papers published in *Lubrication Engineering*, Volumes 1 through 10 (1945 through 1954). $.50. Foreign $1.00

PETROLEUM-TYPE HYDRAULIC FLUIDS

Second in monograph series covers Hydraulic Oil Specifications and Service Properties, Viscosity, Viscosity Index, Demulsibility, Oxidation Stability, Lubricating Value, Rust and Corrosion Preventive Qualities. $1.00. Foreign $2.00

PHYSICAL PROPERTIES OF LUBRICANTS

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PRODUCT LITERATURE

BOOKLET ON SYLOIDS

A new technical booklet describes typical chemical and physical properties as well as applications of 11 Davison Syloid micro-size silica products used for such purposes as flatting, anti-blocking, thickening and moisture removal, and in adhesives and insulation. To meet application requirements, the products cover a wide range of variation in density, particle size, pH, surface area, density, oil absorption, and other characteristics. "The Davison Family of Syloid Silicas" is obtainable on application to Industrial Chemicals, Davison Chemical Division of W. R. Grace & Co., Baltimore 3, Md.

HYDRAULIC TUBE FITTINGS

A 28-page catalog devoted to the complete line of hydraulic tube fittings manufactured by Flodar Corp. is now available. The new catalog is divided into three sections covering self-flaring fittings, no-flare fittings and flare-type fittings. Each section contains complete information on the design and installation of the particular type covered plus detailed dimensional and engineering specifications. Information on all popular shapes and sizes from ⅛" to 2" are included. Several pages are devoted to specifications on high pressure steel pipe fittings commonly used in hydraulic systems. Copies of Catalog #556 are available from Flodar Corp., 16911 St. Clair Ave., Cleveland 10, Ohio.

SUN OIL BOOKLET

A new revision of Technical Bulletin B-4, "Hydraulic Fundamentals and Industrial Hydraulic Oils" has been issued by Sun Oil Company. This 44-page book is a practical introduction to the principles of hydraulic systems, with illustrated explanations of the most important types of valves, pumps, motors, torque converters, and accessories. An explanation of important oil characteristics is followed by sections on oil selection and trouble-shooting. For copies of Technical Bulletin B-4, write to Sun Oil Company, Philadelphia 3, Pa.

DIESTER FLUID BASE

Emolein 2910 lubricant ester, a new diester fluid base for synthetic lubricants, is the subject of a 10-page technical bulletin by Emery Industries. It lists specifications and characteristics for the product and gives suggested starting formulas for synthetic lubricating fluids and greases. Primary advantage claimed for Emolein 2910 is that it enables the compounding of lower cost synthetic lubricants without sacrificing critical performance characteristics. Copies of Technical Bulletin No. 411, titled "Emolein 2910 Lubricant Ester," are available upon request from Emery Industries, Inc., Dept. 5, Carew Tower, Cincinnati 2, Ohio.

ESTIMATING HANDBOOK

The National Screw Machine Products Association has prepared an estimating handbook designed to provide a modern, thorough guide to estimating screw machine products for both independent producers and company-operated screw machine departments. Topics covered in the handbook include: basic quoting procedures and qualifications; materials; estimating production on various equipment; setup, operating, administrative and other cost; specific examples of estimating; and estimating forms and aids. Titled "Estimating Manual for the Screw Machine Products Industry," the handbook is available to buyers of screw machine products as well as qualified producers. For information on price, contact National Screw Machine Products Association, 2860 E. 130th St., Cleveland 20, Ohio.

HEAT DIFFUSER BOOKLET

An informative brochure explaining the company's new line of direct-fired heat diffusers is being offered by Carrier Corporation. The illustrated booklet describes the various installations in which the space heating plant is featured as a low cost central system for schools, churches, warehouses, factories and other large-area buildings. Typical uses of the heat diffuser are shown for heating and ventilating, with air conditioning, for central heating and in manufacturing processes. A step-by-step formula for selecting the proper capacity unit is included, along with tables showing ratings and physical data, fan performance and resistances of filters and other accessories. The booklet can be obtained by writing for Catalogue 46 AF 91, from the Unit Heater Department, Carrier Corp., 300 South Geddes St., Syracuse 1, N. Y.

"CHEMETRON" BROCHURE

A new brochure describing activities of the entire company has been published by Chemetron Corporation, formerly named National Cylinder Gas Company. The 32-page illustrated brochure contains sections on products and services of the company's seven divisions and its subsidiaries and affiliate companies and features the first history of the company. Copies may be obtained from Chemetron Corporation, 840 N. Michigan Ave., Chicago 11, Ill.

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Patent Abstracts . . . . . .

Compiled by Ann Burchick
Aluminum Co. of America

Grease Composition, Patent 2,790,770 (M. Fainman and R. A. Swenson, assignors to Standard Oil Co.) A lubricating grease composition which essentially comprises an oleaginous base thickened by a metal soap grease thickener, a lead soap of sulfurized tall oil, an oil soluble organic polysulfide and a second oil miscible lead soap in an amount increasing the ratio of lead to sulfur in the composition to the range of about 2:1 to 4:1.

Lubricating Composition, Patent 2,790,-771 (A. F. Prust, assignor to Republic Steel Corp.) A synthetic lubricant, for use in lubricating metal cutting knives, said lubricant having good cold metal lubricity and film strength characteristics and chemical and physical stability, said lubricant consisting essentially of an oleic soap of triethanolamine and free triethanolamine and having properties resulting from its preparation by mixing triethanolamine and oleic acid together in the ratio of about 2 parts and about 30 parts of oleic acid to between about 98 parts and about 70 parts of triethanolamine.

Cutting Oil Composition, Patent 2,790,-772 (E. C. Hughes and H. M. Stine, assignors to The Standard Oil Co.) A cutting oil comprising a mineral oil and from about 0.5 to about 5% by weight of a mixture of organic polysulfides.

Cutting Oil Composition, Patent 2,790,-773 (H. M. Stine, assignor to The Standard Oil Co.) A cutting oil concentrate consisting essentially of about 60% by weight of a dimethylbenzyl polysulfide.

Cutting Oil Composition, Patent 2,790,-774 (E. C. Hughes, H. M. Stine, and S. M. Darling and Chien-wei Liao, assignors to The Standard Oil Co.) A cutting oil comprising a mineral oil and from about 0.5 to about 5% by weight of a mixture of organic dipolysulfides.

Cutting Oil Composition, Patent 2,790,-775 (E. C. Hughes and H. M. Stine, assignors to The Standard Oil Co.) A cutting oil consisting essentially of an oil-soluble sulfurized mineral cutting oil base containing between 1 and about 60% by weight of dimethylbenzyl tetrasulfide containing an average of about 4 sulfur atoms in the sulfur bridge.

Water-Resistant Gels and Their Manufacture, Patent 2,790,776 (W. E. Savage and W. H. Peterson, assignors to Shell Development Co.) A process for the preparation of a grease composition which comprises mixing a hydrogel of an amorphous inorganic colloid with from about 10% to about 100% by weight, based on the colloid, of a hydrophobic surface-active agent and from about 50% to about 150% based on the weight of colloid of a lubricating oil, spray drying the mixture so formed to produce a pulverulent material and dispersing it in a lubricating oil to form a grease composition containing from about 1% to about 20% by weight of the colloid.

Rust Preventive Composition, Patent 2,791,510 (L. W. Sproule and J. L. Tiedje, assignors to Esso Research & Engineering Co.) A rust inhibiting composition of the solvent and film type consisting essentially of about 8 to 12% by weight of paraffin wax of melting point between 100 and 120 F. and molecular weight between 300 and 400, 1 to 5% of a partial long chain fatty acid ester of polyhydric alcohol, and a major proportion of a predominantly non-aromatic hydrocarbon solvent having a boiling range between 150 and 450 F., said paraffin wax being soluble in said solvent.

Combination Additive for Mineral Lubricating Oils, Patent 2,791,559 (E. B. Cyphers and R. P. Nejak, assignors to Esso Research & Engineering Co.) A lubricant composition consisting essentially of a paraffin-base lubricating oil, in the range of about 0.1 to 1.0% by weight of 2,2'-methylenebis (4-methyl-6-tert.-butylphenol) and in the range of 0.2 to 2.0% by weight of zinc naphthenate obtained from petroleum naphthenic acids having an average molecular weight in the range of about 200 to 300.

Lubricating Grease Thickened with a Sodium or Lithium Soap and Indigo, Patent 2,791,560 (J. P. Dilworth and J. R. Roach, assignors to The Texas Co.) A lubricating grease consisting essentially of an oleaginous liquid lubricating base thickened to a grease consistency with about 5 to 20 percent by weight based on the weight of the composition of indigo in finely divided form and about 5 to 20 percent by weight based on the weight of the composition of a soap selected from the group consisting of sodium and lithium soaps of fatty acids containing from 12 to 16 carbon atoms per molecule.

Stabilized Diester Lubricant, Patent 2,792,346 (A. W. Lindert, assignor to Standard Oil Co.) A lubricant consisting essentially of about 90 to 95 percent of a diester of a dicarboxylic acid containing about 4 to 8 carbon atoms per molecule, the added ester groups having a carbon chain length of about 5 to 15 carbon atoms, about 4 to 6 percent tricresyl phosphate, about .3 to .7 percent phenothiazine and about .5 to 5 weight percent dilauryl selenide.

Process for Maintaining High Oxidation Stability in Refining of Lubricating Oils, Patent 2,793,982 (J. W. Tierney and R. E. Taylor, assignors to The Pure Oil Co.) The method of preparing mineral lubricating oil stocks exhibiting good resistance to oxidation comprising treating a deasphalted, dewaxed and solvent refined lubricating oil fraction of Mid-Continent origin, containing in excess of 0.2 weight percent of total sulfur present as naturally-occurring sulfur compounds, with commercial grade 20-200 mesh silica gel having an apparent density of about 40-50 lb./cu. ft. to reduce said sulfur content to a minimum of not less than 0.1 weight percent nor more than 0.2 weight percent based on the lubricating oil.

Mineral Oil Base Lubricant, Patent 2,-793,999 (Wilhelm Dietrich, Hans-Joachim Mertens and Fritz Wetter, assignors to Chemische Werke Huls Aktiengesellschaft) A lubricant consisting essentially of a lubricating medium selected from the group consisting of mineral oils and greases, a nitro compound selected from the group consisting of aliphatic and aromatic nitro compounds in the range from 0.05 to 1% by weight and a sulfurized low molecular weight aromatic substituted olefine in the range from 0.5 to 10% by weight, both additions being calculated on the weight of the pure lubricating medium, said sulfurized low molecular weight aromatic substituted olefine being a compound.

Emulsifiable Oil Composition, Patent 2,794,000 (P. M. Ruedrich, assignor, by mesne assignments, to Nopco Chemical Co.) The process for the manufacture of an emulsifier which comprises: reacting at a temperature between about 300 F. and about 375 F. a mixture of fatty acid having at least eight carbon atoms per molecule, ethylenediamine tetraacetic acid and a stoichiometric excess of a dialkanolamine until between 90% and 96% of the total acid value is consumed in a water-splitting reaction and removing from the product the water so split off, the ethylene-diamine tetraacetic acid being present in said mixture in an amount between about 4 and 8 mol percent of the total acid.

Nonspreading Lubricant, Patent 2,794,-037 (J. S. Martin, Jr., assignor to Ham-

ilton Watch Co.) A spread resistant lubricant, comprising alpha-phenyl, gamma-caprylate glycerol, characterized by having a pour point of —40 F., a coefficient of friction of .08, a good resistance to spread and a low evaporation rate.

Basic Zinc Dialkyl Dithiophosphates and Methods of Making the Same, Patent 2,794,780 (V. P. Wystrach, E. O. Hook and G. L. Christopher, assignors to American Cyanamid Co.) A hydrocarbon mineral lubricating oil composition comprising a relatively large proportion of a hydrocarbon mineral lubricating oil having dissolved therein a relatively small amount from about 0.1% to about 5% by weight, sufficient to inhibit deterioration of the oil by oxidation, of a basic zinc dithiophosphate.

High Temperature Aromatic-Free Mineral Lubricating Oil Compositions, Patent 2,794,781 (H. Diamond and C. L. Mahoney, assignors to Shell Development Co.) A lubricating composition comprising a major amount of an aromatic-free essentially isoparaffinic lubricating oil obtained by isomerizing a paraffin wax in the presence of hydrogen and an isomerizing catalyst at a temperature between about 300 C. and 550 C. and thereafter dearomatizing the oil and incorporating therein a minor, but oxidation-stabilizing amount, of an oil-soluble cadmium salt of a thiocarbamic acid.

Anti-Rust Emulsion Resistant Mineral Oil Composition, Patent 2,794,782 (E. P. Cunningham and D. W. Dinsmore, assignors to Monsanto Chemical Co.) An anti-rust mineral oil fraction containing dissolved therein (a) between about 0.001% and about 50% by weight based on the mineral oil of the reaction product obtained by reacting an aliphatic monocarboxylic acid containing from 10 to 30 carbon atoms with a polyalkylenepolyamine of the formula $H_2N(C_2H_4NH)_zH$, wherein z is an integer from 2 to 6 inclusive, to produce an intermediate product and reacting an alkenyl succinic acid anhydride wherein the alkenyl radical contains from 8 to 18 carbon atoms with said intermediate product, the said reaction product dissolved in the said mineral oil fraction providing a solution characterized by being normally susceptible to the formation of oil-in-water emulsions in the presence of water, and (b) between about 0.001% and about 15% by weight based on the mineral oil of a dimeric acid produced by the condensation of unsaturated aliphatic monocarboxylic acids having between about 16 and about 18 carbon atoms per molecule.

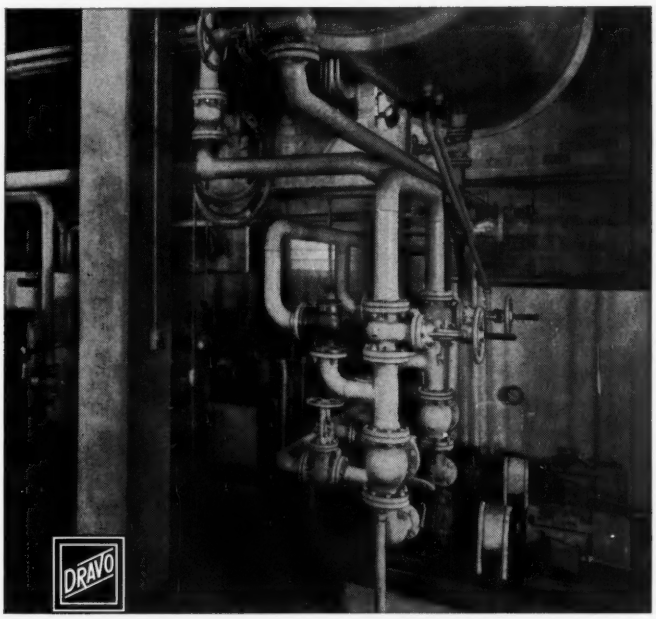
Contact Filtration of Lubricating Oils, Patent 2,795,535 (G. W. Crosby, LeRoy W. Holm, R. W. Morrison and W. J. Sandner, assignors to The Pure Oil Co.) In a process for reducing the neturalization value of a lubricating oil the step which comprises intimately contacting at a temperature of about 350-550 F. an organic acid-containing lubricating oil with 3-15 pounds per barrel of oil of a hydrous alumino-silicate adsorbent from which substantially all of the bound water is removed without deleteriously effecting the structural water content of said absorbent for a time sufficient to produce a substantial improvement in the neutralization value reduction of said oil, said contacting being conducted in the absence of air and steam, and maintained in an anhydrous condition by stripping during said contacting any moisture which is produced during said contacting.

Lubricating Grease Compositions Containing O,N-Diacyl-p-Aminophenols, Patent 2,795,546 (D. W. Young, A. J. Morway and D. L. Cottle, assignors to Esso Research & Engineering Co.) A lubricating grease composition consisting essentially of a lubricating oil thickened to a grease consistency with a metal soap of a fatty acid having combined therein a minor, but oxidation resistance improving amount, of a compound.

Lubricating Oil Compositions, Patent 2,795,547 (O. L. Harle and J. R. Thomas, assignors to California Research Corp.) A lubricant composition comprising an oil of lubricating viscosity and boron ethyl acetoacetate in an amount sufficient to inhibit corrosion.

Lubricant Compositions, Patent 2,795,548 (J. R. Thomas and O. L. Harle, assignors to California Research Corp.) A lubricant composition consisting essentially of an oil of lubricating viscosity and a member of the group consisting of bo-

DRAVO-DeLAVAL Lubrication Systems for Bowaters



Oil cellar for one of the lubricating systems at Bowaters Southern Paper Corporation, Calhoun, Tennessee.

Three Dravo-designed systems automatically lubricate the dryer roll sections of the huge Fourdrinier paper machines at Bowaters Southern Paper Corporation's plant at Calhoun, Tennessee. A fourth system supplies oil for fourteen pulp grinders of which six are driven by 6000 hp motors and eight by 4500 hp motors.

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rates of alpha- and beta-glycols of 2 to 18 carbon atoms and 4-tert.-butyl pyrocatechol in an amount sufficient to inhibit corrosion.

Lubricating Oil Compositions, Patent 2,795,549 (A. D. Abbott, O. L. Harle and J. R. Thomas, assignors to California Research Corp.) A lubricant composition consisting essentially of a mineral lubricating oil for internal combustion engines containing minor amounts of alkaline earth metal petroleum sulfonate and alkaline earth metal alkyl phenate which is normally corrosive to alloy bearings and from about 0.01 to about 5.0 percent by weight based on the oil of a vanadate of alpha- and beta-glycols of 6 to 10 carbon atoms.

Lubricating Oil Compositions, Patent 2,795,550 (O. L. Harle, J. R. Thomas and A. D. Abbott, assignors to California Research Corp.) A lubricant composition consisting essentially of a mineral lubricating oil for internal combustion engines containing minor amounts of alkaline earth metal petroleum sulfonate and alkaline earth metal alkyl phenate, which is normally corrosive to alloy bearings, and from 0.01 to about 5.0 percent by weight based on the oil of a member of the group consisting of glycolic acid molybdate and oxalic acid molybdate.

Lubricant Compositions, Patent 2,795,-551 (O. L. Harle, and J. R. Thomas, assignors to California Research Corp.) A lubricant composition comprising an oil of lubricating viscosity and a member of the group consisting of arsenites, arsenates, antimonites, and antimonates of alpha- and beta-glycols of 6 to 10 carbon atoms and 4-tert.-butyl pyrocatechol in an amount sufficient to inhibit corrosion.

Lubricant Compositions, Patent 2,795,-552 (W. Lowe, assignor to California Research Corp.) A lubricant composition comprising an oil of lubricating viscosity and a member of the group consisting of titanates of alpha- and beta-glycols of 6 to 10 carbon atoms in an amount sufficient to inhibit corrosion.

Lubricating Compositions, Patent 2,796,-400 (G. H. Thornley, assignor to C. C. Wakefield & Co. Ltd.) A lubricating composition consisting essentially of a mixture of castor oil, mineral oil and at least one ester selected from the group consisting of the aliphatic and cycloaliphatic alcohol esters of organic dicarboxylic acids.

Complex Formal Lubricating Composition, Patent 2,796,401 (A. H. Matuszak, W. E. McTurk, D. L. Cottle and D. W. Young, assignors to Esso Research & Engineering Co.) As a synthetic lubricant, a complex formal having an ASTM pour point below about 35 F., a flash point above about 300 F., and a kinematic viscosity at 210 F. within the range of from 2 to 60 centistokes.

Extreme Pressure Lubricant Compositions, Patent 2,796,402 (H. D. Kluge and T. C. Roddy, Jr., assignors to The Texas Co.) A lubricating composition comprising an oleaginous material selected from the group consisting of hydrocarbons, esters, polyethers, and mixtures thereof having lubricating properties as the major component and a minor amount sufficient to impart extreme pressure properties thereto of a 2-thiono-4-ketothiazolidine compound.

Extreme Pressure Lubricant Compositions, Patent 2,796,403 (H. J. Watson and H. D. Kluge, assignors to The Texas Co.) A lubricating composition comprising a mineral lubricating oil as the major component and a minor amount sufficient to impart anticorrosive properties thereto of a 3-hydrocarbon-substituted rhodanine compound.

Extreme Pressure Lubricant Compositions, Patent 2,796,404 (H. Levin, assignor to The Texas Co.) A lubricating composition comprising a mineral lubricating oil having lubricating properties as the major component and a minor amount sufficient to impart extreme pressure and anticorrosive properties thereto of a 5-alkylaminobenzylidenerhodanine compound.

COMING EVENTS

September 14-19

Instrument-Automation Conference and Exhibit, Convention Hall, Philadelphia, Pa.

September 24-25

National Association of Corrosion Engineers, Guided Field Corrosion Tour, San Joaquin Valley, Calif.

September 23-26

Iron and Steel Exposition and Convention, Cleveland Auditorium, Cleveland, Ohio

September 30-October 1

National Screw Machine Products Association Executive Seminar, Brock-Sheraton Hotel, Niagra Falls, Canada

October 1-2

Radio Interference Reduction Conference, Museum of Science and Industry, Chicago, Ill.

October 13-15

National Electronics Conference, Hotel Sherman, Chicago, Ill.

October 13-15

ASLE-ASME Lubrication Conference, Hotel Statler, Los Angeles, Calif.

October 27-29

NLGI 26th annual meeting, Edgewater Beach Hotel, Chicago, Ill.

(*Cont. from p. 337*)

the necessity for overhaul, provided that bearing seals and other machinery housings are properly gasketed to retard windage and penetration of dust into chain and gear cases or into other lubricant reservoirs.

Past history and records as to parts replacement and other maintenance procedures are valuable as a guide to overhaul periods and the relation to cleanliness. By calculating the cost of time loss and product interruption when a machine is down for overhaul and by balancing this combined monetary value against the relatively insignificant cost of cleaning, the production value of the latter is self-evident.

While effective lubrication is based on a number of requirements such as suitability of the lubricant for the operating conditions, the method of application, facilities for protection, and cleanliness it is important to remember that some types of lubricants are self-protecting, so to speak. We have in mind the heavy duty motor oils which, by virtue of inclusion of a dispersive additive, are capable of carrying in suspension finely divided insoluble particles which result from oil decomposition and engine fuel combustion. This property of dispersion prevents such contaminants from causing sludge build-up on engine oil filters, in bearing grooves or elsewhere to retard oil circulation. Provided that the oil filter is functioning and periodic draining and replacement with new oil is carried out, engine overhaul can be postponed indefinitely.

Lubrication of Outboard Motors

(*Cont. from p. 342*)

Engines that are over-cooled will show extensive cylinder wall rusting in storage unless given special treatment. It has been found from practical experience that choke-stopping the engine before such storage periods is definitely beneficial. However, even in such cases, it depends upon the lubricant in the gasoline having adequate anti-corrosion properties to afford the protection necessary.

8. GUM FORMATION. The formation of gum on carburetor and other parts contacting the gasoline hardly seems to be a function of the lubricating oil. However, it is hoped that oil producers can provide an additive that inhibits the formation of gum. It is important to guard against gum formation, as the outboard motor is frequently laid away for extended periods of time. It is not unusual for storage to extend several years without draining fuel from the system.

9. ACTION ON RUBBER PARTS. Rubber parts used in the fuel system are normally considered resistant to gasolines as used in the United States. In the development of an outboard oil, it would be well to keep in mind that additives damaging to rubber parts should be avoided.

10. THE EFFECTS OF LEAD IN THE GASOLINE. It is hoped that in the development of a special outboard motor oil, an additive to reduce effects of leaded fuels, particularly on the spark plug and combustion chamber deposits, can be incorporated.

CONCLUSIONS

The two-cycle engine industry feels that much is to be gained if petroleum products could be developed to specially meet the needs of the outboard engine. Admittedly, engine manufacturers can do considerably more toward adapting their products to existing fuels and lubricants. But, to build more efficient two-cycle engines that will better meet the needs of an ever-growing market, it would be highly desirable to have the active cooperation of the petroleum industry in developing specific products for the purpose.

AN OMISSION The name of E. F. Houghton & Co. was inadvertently omitted from the list of industrial members in the April 1958 ASLE *Transactions*. E. F. Houghton & Co. is a long-time member of the society.

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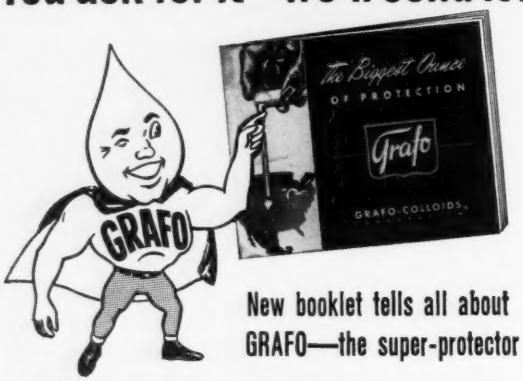

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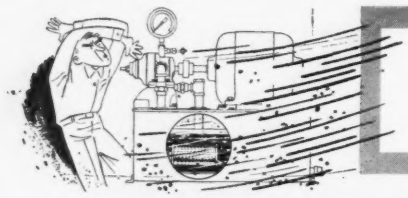

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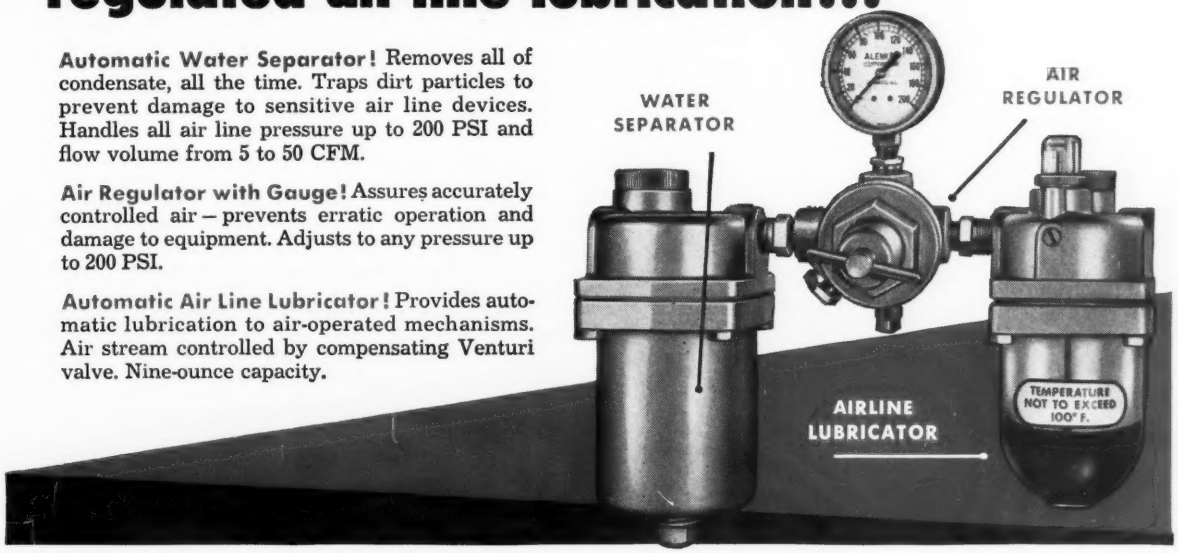

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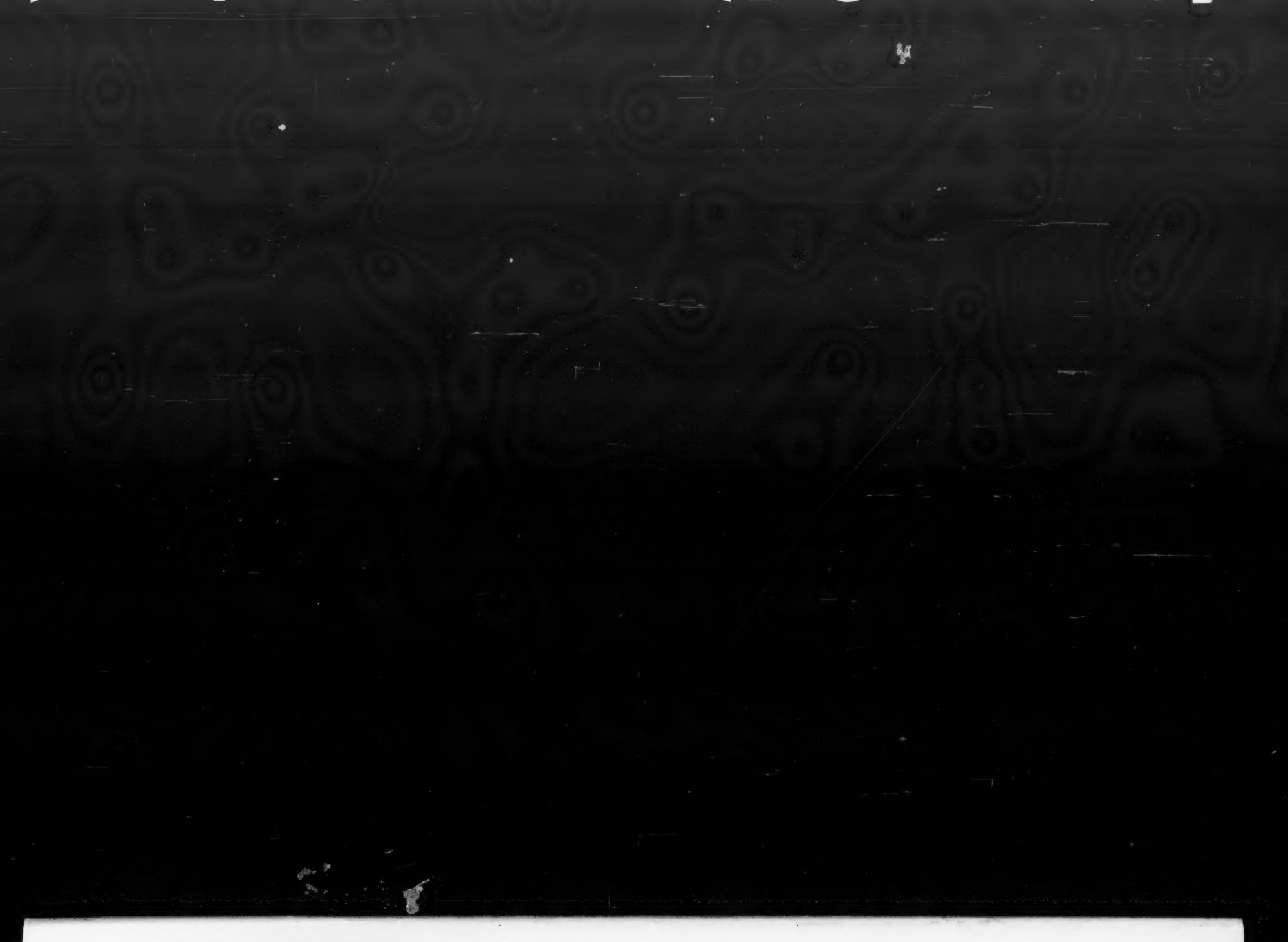
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